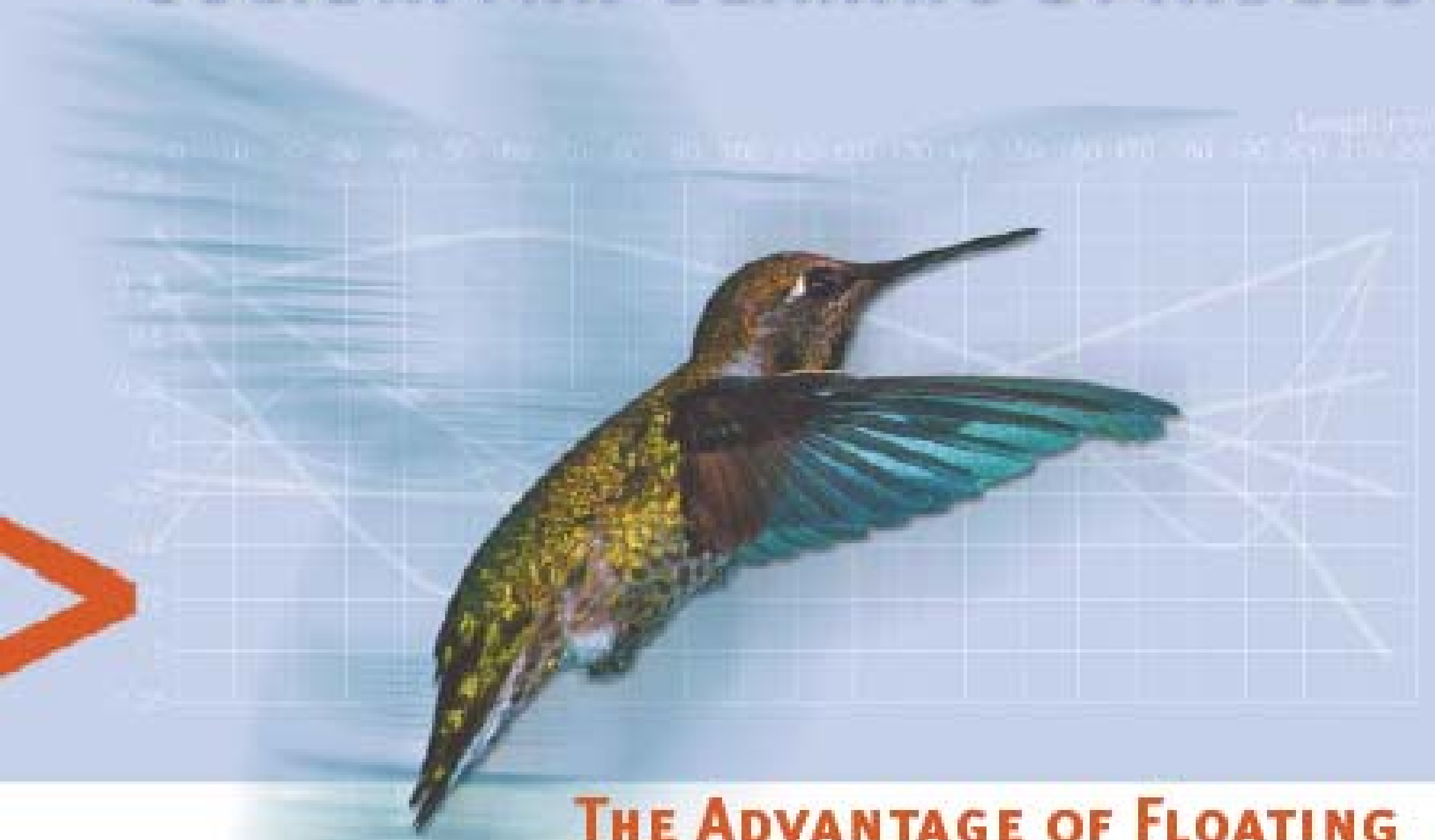
COLIBRI AIR-BEARING SPINDLES



THE ADVANTAGE OF FLOATING

Manual Book:
BOH 80 2.1 D 60

High stability

Contamination-free process

Revolutionary compact design

High-speed rotation

COLIBRI
AIR-BEARING SPINDLES

COLIBRI
AIR-BEARING SPINDLES

The miniature Colibri hummingbird hovers motionless in the air, its brilliant wings beating with the highest frequency of any type of bird.

Colibri Spindles's patent-pending technology floats a high-speed shaft in an exceptionally compact air-bearing to provide unsurpassed spindle performance.

■ FLOATING ■ HIGH-SPEED ■ COMPACT ■ SMART

THE ADVANTAGE OF FLOATING

Spindles Aerostatics

Charactersitics

In most respects aerostatic bearings are ideally suited for use in high-speed machines. Their low friction provides high mechanical efficiency and minimizes bearing heating problems.

They are quiet and smooth running and do not add to sound and vibration levels of the machine in the way that high-speed ball bearing do.

Applications

One of the most important fields of application of aerostatic bearings is undoubtedly on machine tools where the range of machine tool application is very wide.

Advantages

Almost all of the benefits result from three properties of aerostatic bearings: low friction, precise axis definition, and the absence of wear. In comparison with spindles with ball or roller bearings, the lower level of vibration of aerostatic bearings is an important advantage. This is particularly true in relation to the production of good work piece geometry and surface finish, and in ensuring long life of the cutting tool, drill or grinding wheel.

Aerostatic bearings have been employed in machines driven by most types of electric motors and most types of turbines. They have also been employed in a wide range of machine tool spindles driven by various types of belts and flexible couplings. In all these cases the driving torque is evenly and smoothly applied, excepting the case of driving by means of a belt, the drive does not apply large loads to the bearings. Aerostatic bearings are most successful when operating under these conditions. They are much less likely to be successfully applied to machines with pulsating drives, which impose large internal loads on the bearings.

CONTENTS

FUNDAMENTAL SAFETY INSTRUCTIONS

1. Basic operation and designated use of the machine.

1.1 The machine has been built in accordance with state of the art standards and recognized safety rules. Nevertheless, its use may constitute a risk to life and limb of the user and of the third parties, or cause damage to the machine and to other material property.

1.2 The machine must only be used in technically perfect conditions in accordance with its designated use and the instructions set out in the operation manual. Only safety-conscious persons who are fully aware of the risks involved in operation the machine should operate it. Any functional disorders, especially those affecting the safety the safety of the machine, should therefore be rectified immediately.

1.3 The machine is designed exclusively for drilling, grinding and milling operations. Using the machine for purposes other than those mentioned above is considered contrary to its designated use. The manufacturer cannot be held liable for any damage resulting from such use. The risk of such misuse lies entirely with the user. Operating the machine within the limits of its designated use also involves observing the instructors set out in the operation manual and complying with the inspection and maintenance directives.

2. Organizational measures.

2.1 The operating instructions must always be at hand at the place of use of the machine.

2.2 In addition to the operating instructors, observe and instruct the user in all other generally applicable legal and other mandatory regulations relevant to accident prevention and environmental protection. Those compulsory regulations may also deal with the handling of hazardous substances, issuing and/of wearing personal protective equipment.

2.3 The operations instructions must be supplemented by instructions covering the duties involved in supervising and notifying special organizations, working sequences or the personal entrust with the work.

2.4 Personal entrust with the work on the machine must have read the operating instructions and in particular the chapter on safety before beginning work. Reading the instructions after work is too late. This applies especially to persons working only occasionally on the machine e.g. during setting up or maintenance.

2.5 Check whether personal is carrying out the work in compliance with the operation instructions and paying attention to risks and safety factors.

2.6 For reasons of security, long hair must be tied back or otherwise secured, garment must be close fitting and no jewelry, such as ring, may be worn. Injury must result from being caught up in the machinery or from rings catching on moving parts.

2.7 Use protective equipment whenever required by the circumstances or by law.

2.8 Observe all safety instructions and wearing attached to the machine.

2.9 See to it that safety instructions and wearing attached to the machine are always complete and perfectly legible.

2.10 In the event of safety-relevant modifications or changes in the behavior of the machine during operation, stop the machine immediately and report the malfunction to the competent person.

2.11 Never make any modifications, additions or conversions, which might affect safety without the suppliers' approval. This also applies to the installation and adjustments of safety devices and valves.

2.12 Spare parts may comply with the technical requirements specified by the manufacturer. Spare parts from original equipment manufacturers can be rely to do so.

2.13 Never modify the software of programmable control systems.

2.14 Adhere to prescribe intervals or those specified in the operating instructions for routine checks and inspections.

2.15 For the execution of maintenance work, tools and workshop equipment adapted to the task on hand are absolutely indispensable.

2.16 A portable fire extinguisher must be placed within immediate reach.

2.17 Observe all fire warning and fire-fighting.

3. Selection and qualification of personal-basic responsibilities

3.1 Any work or and with the machine be executed by reliable personnel only. Statutory minimum age limits must be observed.

3.2 Employ only trained or instructed stuff and set out clearly the individual responsibility of the personnel of operation, set-up, maintenance and repair.

3.3 Make sure that only authorized personnel work on or with the machine.

3.4 Define the machine operators' responsibilities – giving the operator the authority to refuse instructions by third parties that are contrary to safety.

3.5 Do not allow persons to be trained or instructed or persons taking part in a general training course to work on or with the machine without being permanently supervised by an experienced person.
3.6 Work on the electrical system and equipment of the machine must be carried out only by a skilled electrician or by instructed person under the supervision and guidance of a skilled electrician and in accordance with electrical engineering rules and regulations.

4. Safety instructions governing standard operation

4.1 Avoid any operational mode that might be prejudicial to safety.
4.2 Take the necessary precautions to ensure that the machine is used only when in a safe and reliable state.
4.3 Operate the machine only if all protective and safety oriented devices, such as removable safety devices, emergency shut-off equipment, sound proofing elements and exhausts, are in place and fully functional.
4.4 Check the machine at least once per working shift for obvious damaged and defects. Report any changes (including changes in the machine's working behavior) to the competent person immediately. If necessary stop the machine immediately and lock it.
4.5 In the event of malfunction, stop the machine immediately and lock it. Have any defects rectified immediately.
4.6 During start-up and shutdown procedures, always watch the indicators in accordance with the operating instructions.
4.7 Before starting up or setting the machine in motion, make sure that nobody is in risk.
4.8 Never switch off or remove suction and ventilation devices when the machine is in operation.

5. **Safety instructions governing special work in conjunction with utilization of the machine and maintenance and repair during operation; disposal and consumable parts**.

5.1 Observe the adjustment, maintenance and inspection activities and intervals set out in the operation instructions, including information on the replacement if parts and equipment. Skilled personnel may execute those activities only.
5.2 Brief operation personnel before beginning special operations and maintenance wok, and appoint a person to supervise the activities.
5.3 If any work concerning the operation, conversing or adjustment of the machine and its safety oriented devises or any work related to maintenance, inspection and repair always observe the start-up and shutdown procedures set out in the operating and the information on maintenance work.
5.4 Ensure that the maintenance area is adequately secured.
5.5 If the machine is completely shut-down for maintenance and repair work, it must be secured against inadvertent starting by:
   - Locking the principal control elements and/or
   - Attaching the "warning signal" sign to the main switch.
5.6 To avoid the risk of accidents, individual parts and large assemblies being moved for replacement purposes should be carefully attached to lifting tackle and secured. Use only suitable and technically perfect lifting gear and suspension systems with adequate lifting capacity. Never work or stand under suspended loads.
5.7 For carrying out overhead assembly work, always use specially designed or otherwise safety-oriented ladders and working platforms. Never use machine parts as a climbing aid. Wear a safety harness when carrying out maintenance work at greater heights.
5.8 Keep all hardens, steps, handrails, platforms landing and ladders from dirt.
5.9 Clean the machine especially connections and threaded unions, of any trace of oil, fuel, or preservative before carrying out maintenance. Never use aggressive detergents. Use lint-free cleaning rags.
5.10 Before cleaning the machine, cove or tape all openings, which for safety and functional rezones, must be protected against water, steam, or detergent penetration. Special care must be taken with electric motors and switchboard cabinets.
5.11 Always tighten any screwed connections that have been loosened during maintenance work.
5.12 Any safety devices removed for set-up, maintenance or repair purpose must be ratified and checked immediately upon completion of the maintenance work.
5.13 Ensure that all consumable and replaced parts are disposed safely and with minimum environmental impact.

6. Warning of special dangers:

6.1 Use only original fuses with the specified current rating. Switch off the machine immediately if trouble occurs in the electrical systems.

6.2 Work on the electrical system or equipment may only be carried out by a skilled electrician himself or by specially instructed personnel under the control and supervision of such electrician and in accordance with the applicable electrical engineering rules.

6.3 If provided for in the regulations, the power supply to parts of machine, on which inspection, maintenance and repair work has to be carried out, must be cut off. Before starting any work, check the de-energized parts for the presents of power and ground or short-circuit in addition to insulating adjacent live parts and elements.

6.4 The electrical equipment of machine is to be inspected and checked at regular intervals. Defects such as loose connectors or scorched cable must be rectified immediately.

6.5 Necessary work on live parts and elements must be carried out only in the presence of a second whom can cut off the power supply in case of danger by actuating the emergency shut-off or main power switch. Secure the working area with a red-and-white safety tape and a warning sign. Use insulated tools only.

6.6 Check all lines, hose and screwed connections regularly for leaks and obvious damage. Repair damage immediately.

6.7 Depress all system sections and pressure pipes to be removed in accordance with the specific instructions for the unit concerned before carrying out any repair work.

6.8 Compressed air lines must be laid and fitted promptly. Ensure the no connections are interchanged. The fittings, length and quality of the hoses must comply with the technical requirements.

7. Mobile machinery and equipment

7.1 Cut off the external power supply of the machine even if only minor changes of place are envisage. Properly reconnect the machine to the supply mains before restarting.

7.2 For restarting process only in accordance with the operating instructions.

WARRANTY NOTICE

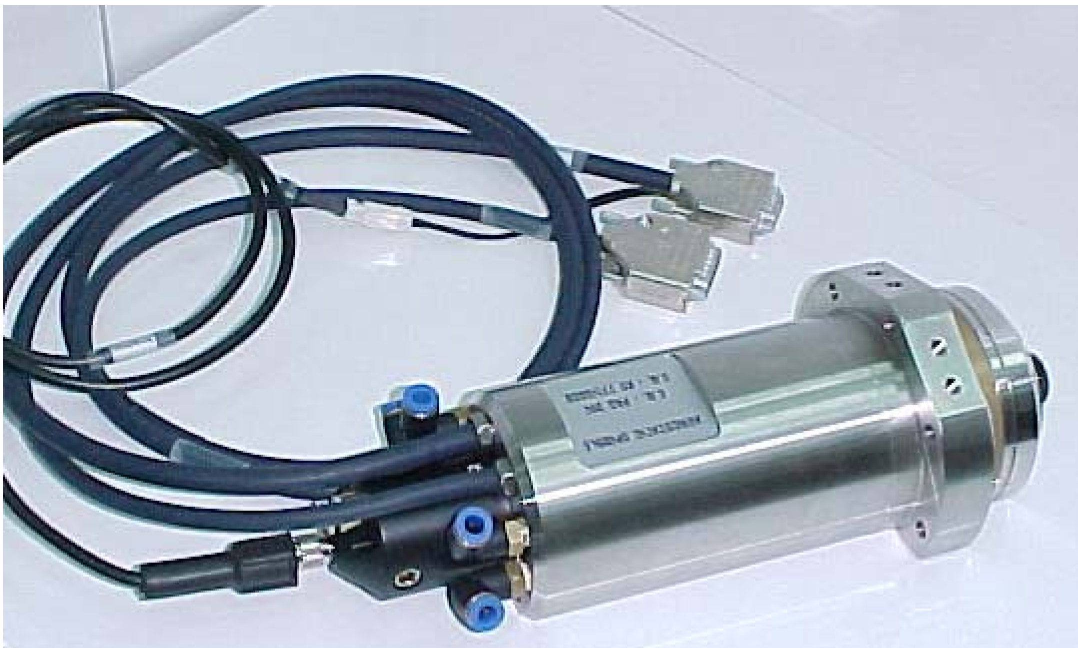
We warrantee this spindle to be free of material and workshop defects. This warrantee is conditional upon proper use in the applications of which this spindle is designed to. Warrantee is void if damaged caused due to improper use, installation, negligence, accident, inadequate maintenance to the spindle or the machine in which it is installed. This warrant is also void if customer did not follow the complete manual and caused damage.

In any case of damage, failure analysis will be perform by Plasel to determine the cause of the failure. Warrant is void if damaged caused by inadequate machine maintenance or improper use ex. Leaky valves, Z-axis leakage wear, contained air supply, lower/higher air presser, inadequate vacuum, using the spindle to work on material that is too hard, drilling into anything other then the right material.

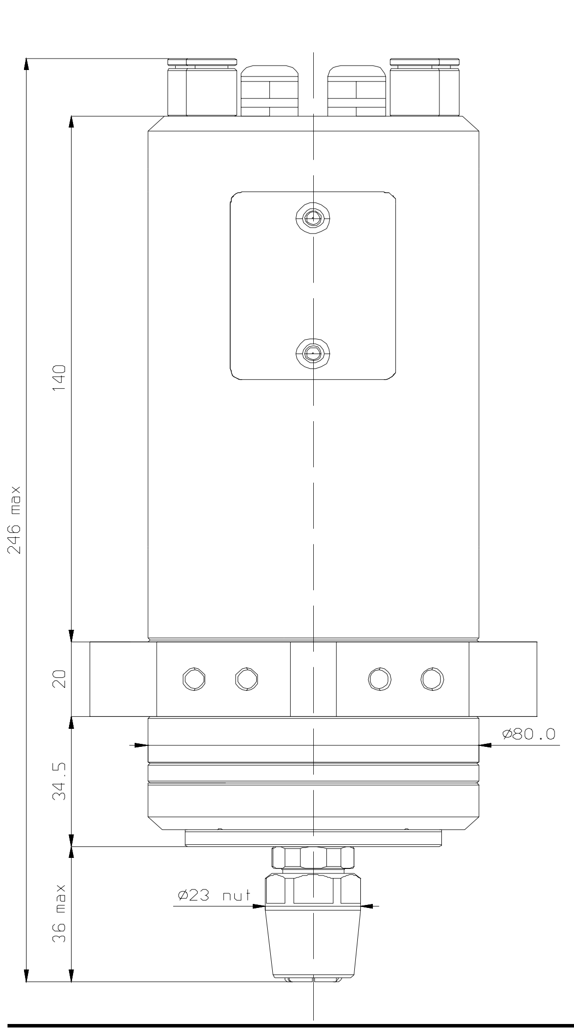
ATTENTION

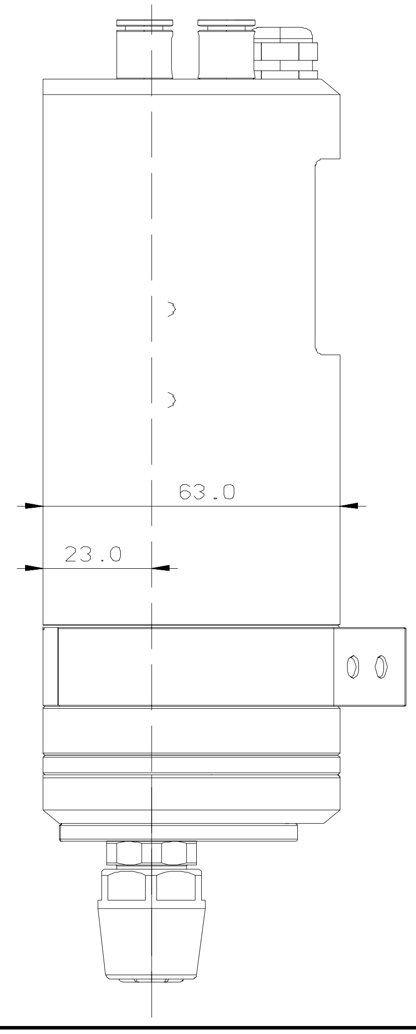
DAILY CHECK BEFORE OPERATING THE SPINDLE

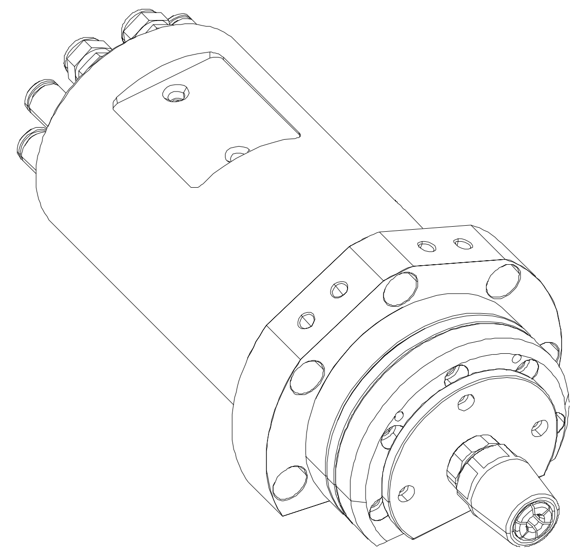
1. For first time installation, look at “Installing the spindle” paragraph.
2. Check air supply (5-6 bar.)
3. Check water supply (4-5 bar.) Check water supply (4-5 bar.)
4. Check ventilation exits.
5. Check for free movement of the shaft.
6. The spindle must be securely clamped to the machine and clear from any distraction.
7. Check for electric connections and command (community grounding).
8. Start the spindle.

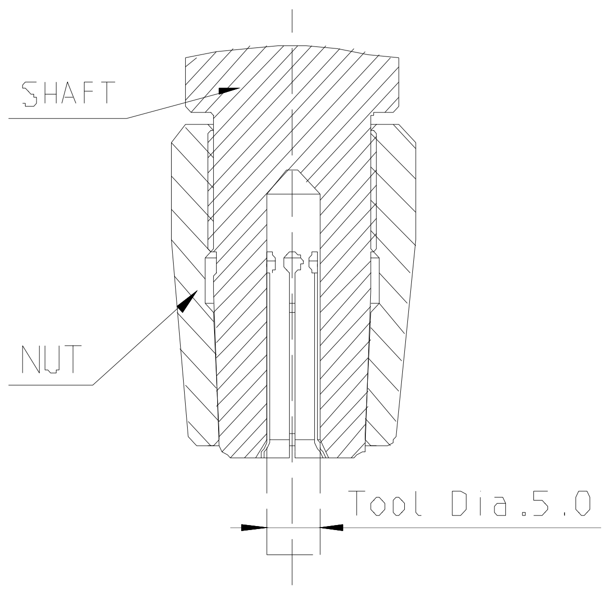


General Description



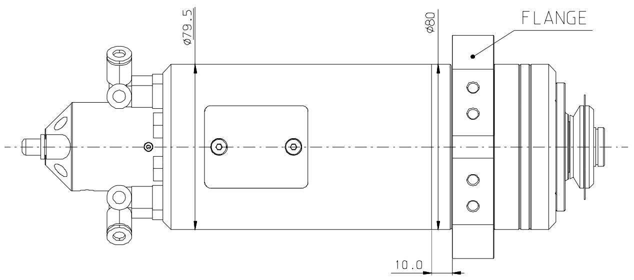


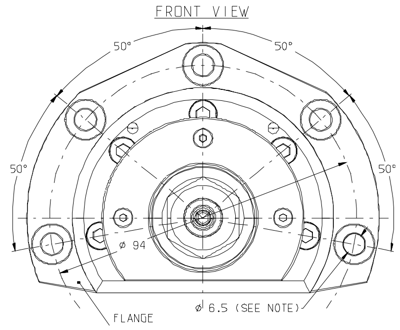




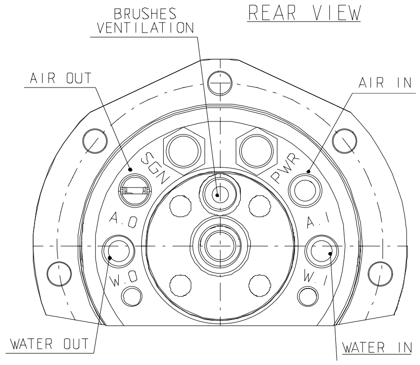
INSTALLING THE SPINDLE

1. Remove the spindle from its package.
2. Follow the machine's safety and installation instructions.
3. Clamp the spindle to the machine - using 5 screws (M6 or 1\4" UNF socked head – minimal length 15 mm).

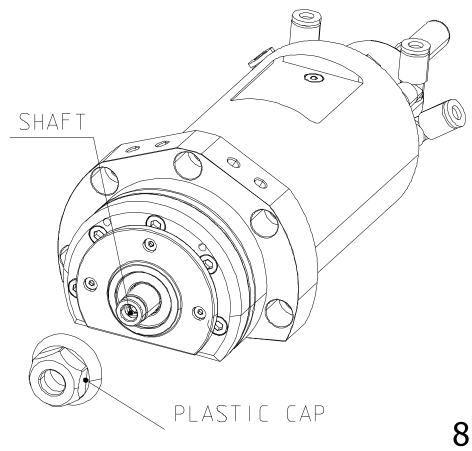




4. Remove plugs from water, air and brushes ventilation connections (5).
5. Connect inlet air pipe Ø6 mm to "AIR IN" (AI).
6. Connect outlet air pipe Ø5 mm to "AIR OUT" (AO).
7. Connect inlet water pipe Ø8 mm to "WATER IN" (WI).
8. Connect outlet water pipe Ø8 mm to "WATER OUT" (WO).
9. Connect Ø 4 mm pipe to brushes ventilation hole (BV).
10. Remove black plastic nut from the end of the shaft.



11. Turn air supply on, spin the shaft by hand and make sure that the shaft is rotating freely.
12. Check for air pressure (4.5-5.5 [bar].)
13. Check for airflow (35-55 [lpm].)
14. Connect signal cable to the driver.
15. Connect power cable to the driver
16. Connect brushes cable to the spindle.
17. Open water pressure on to derivate water leaks.
18. Check for water pressure (4-5 bar)
19. Check for water flow (2.5 – 3.5 [lpm])
20. Turn the driver on and spin the spindle. Start at low speed (5000 rpm for 5 minutes) and slowly increase up to 60 Krpm.
21. Check for motor current at 5000 rpm, less 0.5 Amp.



SPECIFICATION FOR HIGH-SPEED AIR SPINDLE

Rotation speed – 2K ~ 75K [rpm]

Air supply

- Pressure :5~7 [bar]
- Flow rate :45-55 [lpm]
- Filtering :0.01 [µm]
- Dew point :lower then 15 [□C]
- Oil residue :lower then 0.1 [ppm]

PCW (Pure Clean Water – pure H_2O)
Coolant Water

- Pressure (max) : 5 [bar] (72.5 psi)
- Flow rate (min) :1-3.5 [lpm]
- Temperature :20 ~ 25 [oC]
- Variation range :within 1 [oC]

Static run-out of the rotor

- Radial direct.(max) :0.35 [µm]
- Thrust direct (max) :0.35 [µm]

Dynamic run-out of the rotor

- Radial direct(max) :1 [µm]
- Thrust direct.(max) :1 [µm]
- Radial direct. Fluctuation between peaks :0.3 [µm]
- Thrust direct. Fluctuation between peaks :0.3 [µm]

Rigidity of the rotor

- Radial direct. :14 [N/µm]
- Thrust direct. :9 [N/µm]

Load capacity

- Radial direct. :60 [N]
- Thrust direct. :100 [N]

General

- Shaft Axial Extension @ Tm = 40 [oC] :4 [µm]
- Spindle Weight :6.7 [Kg]
- Rotor Inertia :6.5E-5 [Kg*m2]
- Noise level 0 up to 10 Krpm (max) :70 [db a]
- Resistance between shaft & frame :1 [MΩ]
- Balance:G0.4 @ ISO 1940 :0.03 [gmm]
- CE standard : corresponding
- Floating Point : 2 [bar]
- Cables` length: Power cable :1.25 [m]
- Signal cable : 1.3 [m]
- Brushes cable : 1.15 [m]
- Brushes life-time@ 30-40 Krpm : 2500 [hr]
-

Mechanical Coefficient

Air Flow Coefficient :A_f = 38.14
Water Flow Coefficient :W_f = 2.84
Still Air Cooling Efficiently :C_s = 28.8
Air Flow Cooling Efficiently :C_a = 54
Shaft Extension Coefficient :E_S = 0.055
Mechanical Friction Coefficient :F_L = 0.043
Stiffness & Load Coefficient :S_L = 0.417
Thermal Behavior Coefficient :B_t = 3.6^{-4}
Radial Stiffness Coefficient :S_r = 16.487
Axial Stiffness Coefficient :S_a = 10.06
Radial Load Coefficient :L_r = 71.54
Axial Load Coefficient :L_a = 91.84

<u>MECHANICAL COEFFICIENT</u>

A_f Air Flow Coefficient
A_f $= 43*e^{-0.002*Vsp}$ @ $V_{sp} = 60$ [Krpm]

W_f Water Flow Coefficient
W_f = 0.9+1.4*ln {Pw} @ Pw = 4 [bar]

C_s Still Air Cooling Efficiency:(Water Flow Cooling/Still Air Cooling)@60 Krpm
C_s $=80*e^{-0.017*Vsp}$

C_a Air Flow Cooling Efficiency: (Water Flow Cooling/Air Flow Cooling)@60Krpm
C_a $= 82.3*e^{-0.007*Vsp}$

B_t Thermal Behavior Coefficient
B_t $= [(T_r-T_f)^2 + (T_s-T_f)^2 + (T_s-T_r)^2\ ]^{-1/2}$ @ $T_m = 100$ [Cº]

Es Shaft Extension Coefficient
Es = (0.236*Tm – 5.426)-1 @ Tm = 100 [cº]

Sr Radial Stiffness Coefficient
Sr = 13.642*ln(Ps)-7.956 @ Ps=6

Sa Axial Stiffness Coefficient
Sa = 6.425*ln(Ps)-1.454 @ Ps=6

Lr Radial Load Coefficient
Lr = 64.39*ln(Ps)-43.832 @ Ps=6

La Axial Load Coefficient
La = 67.664*ln(Ps)-29.4 @ Ps=6

Fl Mechanical Friction Coefficient
Fl = (6.5*10-3*Vsp2)-1 @ V = 60 Krpm

Sl Stiffness & Load Coefficient
Sl = 7*10-4[4(Sr+Sa)+3(Lr+La)] Sl = 0.417

ELECTRICAL MOTOR SPECIFICATION

- **Size Constants**:
- Maximum Rated Torque : Tr = 2.13 [Nm]
- Maximum Continuous Stall Torque
- @ Temp. Rise 100 [ºC] : Tc = 0.30 [Nm]
- Motor Constant : Km = 0.03 [Nm/$\sqrt{w}$]
- Electrical Time Constant : Te = 0.46 [msec]
- Mechanical Time Constant : Tm = 3 [msec]
- Angular Acceleration (theoretical) : 800000 [rad/sec^2]
- Thermal Resistance : TPR =0 .65 [ºC/watt]
- Maximum Cogging Torque : Tf = 9.180E-03 [Nm]
- Viscous Damping : Fi = 1.038E-07 [Nm/rpm]
- Hysteresis Drag Torque : Th = 2.481E-04 [Nm]
- Rotor Inertia Frameless : Jm = 2.596E-06 [Kg*m^2]
- No. of Poles : P = 6
- **Winding Constants:**
- Design Voltage : Vp = 150 [Volt]
- Peak Torque : Tp = 2.13 [Nm]
- Torque Sensitivity : Kt = 0.02 [Nm/Amp]
- Peak Current : Ip = 120 [Amp]
- No Load Speed : Snl = 8500 [rad/sec]
- Voltage Constant : Kb = 0.02 [v/rad/sec]
- Terminal Resistance : Rm = 0.36 [Ohm]
- Terminal Inductance : Lm = 0.17 [mH]
- **RMS Torque Performance**
- (Performance @ 25 Cº):
- D esign Voltage : Vp = 150 [Volt]
- Continuous Power Output : Power = 1200 [watt]
  : 1.6 [Hp]
- Torque : 0.2 [Nm]
- Speed : 60000 [rpm]
- Iphases : 12.4 [Amp]
- I (dc-link) : 8.75 [Amp]
- Efficiency : 92 [%]
- Temperature Rise : 70 [ºC]
- Ambient temperature : 25 [ºC]
- Cooling : Water cooling
- **Mechanical:**
- Lamination Material : C49
- No. of phases : 3
- Phase Connection : DELTA
- Parallel path : 1
- Turns/Coil : 21
- Wire Gage (AWG) : 27
- Lead wire Gage (AWG) : 24

Brushless DC Motor

Maximum Continuous Stall Torque (T_C) is the amount of torque produce at zero speed, which results in a 100 Cº rise in temperature. Generally the highest operation temperature that should be allowed is 150 Cº and is a combination of the ambient temperature and the temperature rise for a given operating condition.

Maximum rated Torque (T_R) is the amount of torque that the motor can produce without demagnetizing the rotor. The torque is only available for short durations. Also, it may not be possible to produce the Maximum rater torque because of limitations of voltage and current (see peak torque).

Motor Constant (K_M) is the rations of the peak torque to the square root of the input power at stall which 25 Cº ambient temperature. The ratio is useful during the initial selection of a motor since it indicated the ability of the motor to convert electrical power into torque.
K_M = T_P (Peak Torque / $\sqrt{P_P}$ (Peal Input Power)
Or
K_M = K_T (Torque Constant / $\sqrt{R_M}$ (Terminal Resistance)

Electrical Time Constant (t_F) is the ration of inductance (L_M) IN henries, to the resistance R_M IN ohms. This is the inductance and resistance as measured across any two phases in a delta or wye configuration.
$T_E = L_M / R_M$

Mechanical Time Constant (t_M) is the time required to reach 62.3% of the motor maximum speed after the application of constant DC voltage trough the commutation, ignoring friction, wind age and cross losses.
$T_M = J_M * R_M / K_T*K_B$

Thermal Resistance (TPR) correlated winding temperature rise to the average power dissipated in the stator winding. The published TPR assumes that a housed motor is mounted to an aluminum heat sink of specific damnations. Additional cooling from forced air, water jacketing, or increased heat sinking decreases the motor Thermal Resistance allowing higher power output then the published date.

Viscous damping (F_0) gives an indication of the torque lost due to B.E.M.F in the motor when the source impedance is zero. F_0 value can be represented as $F_0 = K_T$ **Maximum Cogging Torque (T_F)** is principally the static friction torque felt as the motor is rotated as low speed. The published value does not include the bearing friction of a housed motor.

Number of Poles (N_P) is the number of permanent magnet poles of the rotor. For the QB Series this is generally a total of six (three north and three south)
Design Voltage (V_P) is the nominal voltage required to produce the peak torque when the rotor speed is zero and the winding temperature is 25 ºC. as such V_P is the product of I_P and R_M. at any temperature greater then 25 ºC, the required voltage to produce peak torque increases due to the increase in winding resistance. The design voltage is <u>not</u> a limit but a reference point for the date.

Peak Torque (t_P) is the nominal value of developed torque with the rated current I_P applied to the windings. For each winding specified the product of peak current (I_P) and nominal torque sensitivity (k_T) gives T_P unless the maximum rated torque (T_R) is reached.

Peak Current (I_P) is the rated current used to obtain the nominal peak torque from the motor with nominal torque sensitivity (K_T). I_P is generally the design voltage divided by the terminal resistance (R_M).

Torque Sensitivity (k_T) is the ratio of the developed torque to the applied current for a specific winding. K_T is related to the BEMF constant K_B.

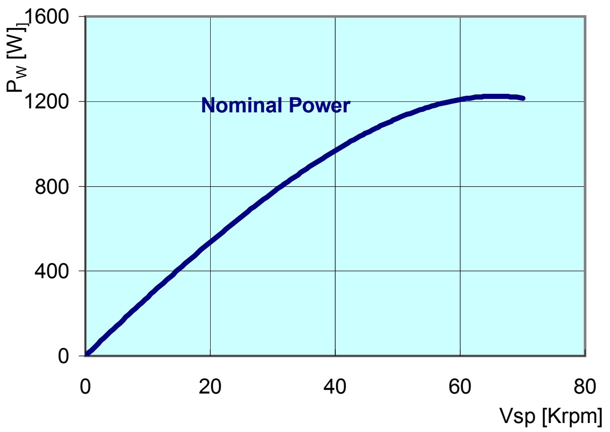
No load Speed (S_{LN}) is the theoretical no load speed of the motor with the design voltage applied.

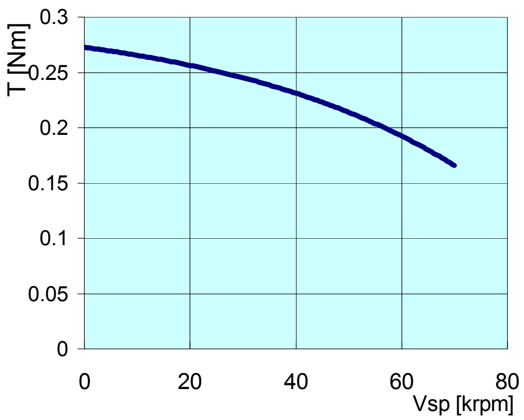
BEMF Constant (k_B) is the ration of voltage generated in the winding to the speed of the rotor. K_B is proportional to K_T.

Terminal Resistance (R_M) is the winding resistance measured between any two leads of the winding in either a delta or wye configuration at 25 ºC.

Terminal Inductance (L_M) is the winding inductance measured between any two leads of the winding in either a delta or wye configuration at 25ºC.

Torque & Power Vs. Rotation Speed





Vsp [Krpm] - Rotation Speed
T [Nm] - Spindle Torque
Pw [w] - Nominal power

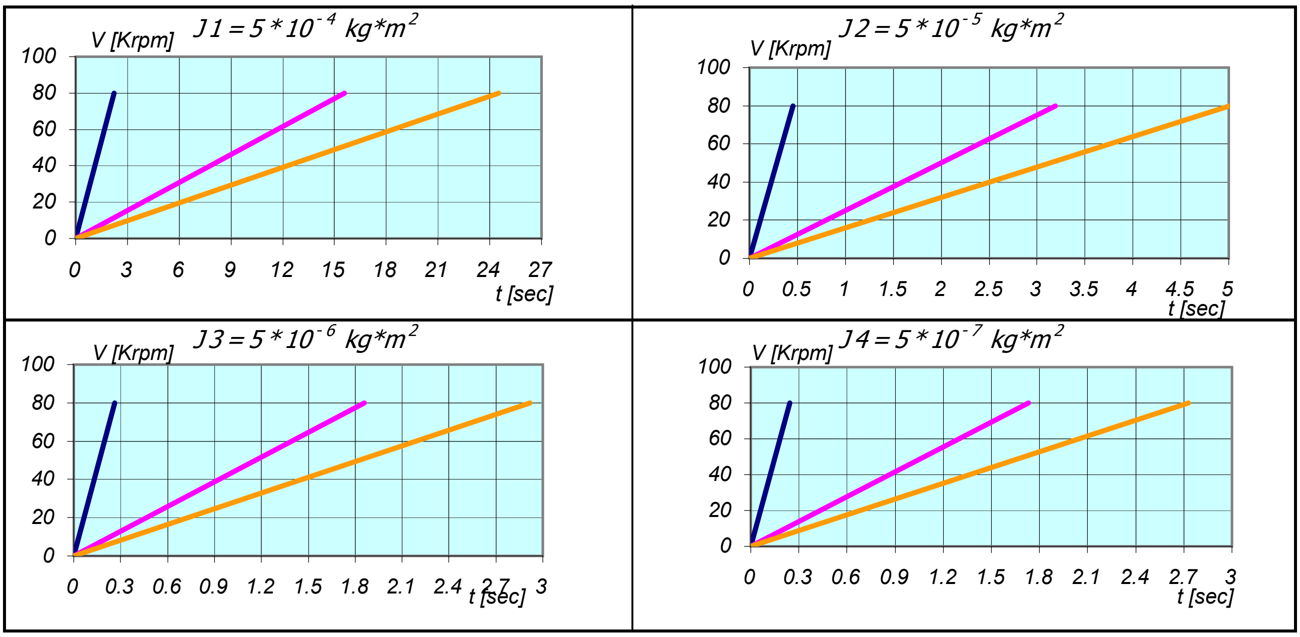
Conditions

1. Temp Rise less then 100° C.
2. Continuous operation at a load point.
3. The curves assume a 25°C ambient environment.
4. No external loads.

Continuous Duty Speed/Torque Curves for 100°C Temperature Rise.

The continuous duty speed/torque curves provide a guide to the operational capability of the motors. Continuous operation at a load point on or under the curve limits the temperature rise of the motor to 100°C. Although the duration of acceleration or deceleration periods should be checked, the RMS speed and torque combination should also lie on or *under the continuous duty curve* .The curves assume a 25°C ambient environment. Higher ambient temperatures will generally decrease the continuous duty capability of a motor. The continuous duty capability of the motor may be increased. However, for most application, the practical maximum motor temperature is 150°C with Hall effect sensors. Higher motor temperatures can easily be accommodated with different materials. EMOTEQ U.K. Ltd

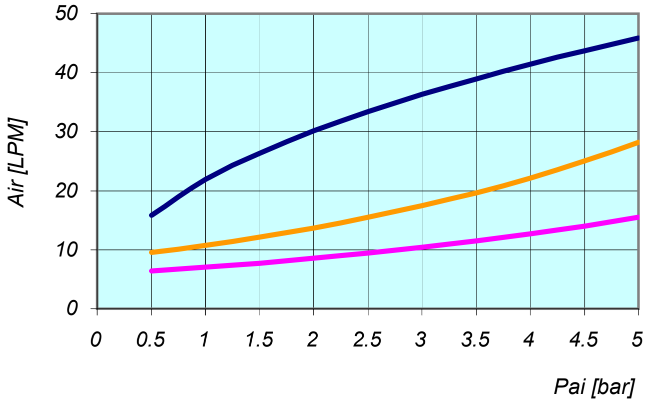
Final Velocity Vs. Torque , Acceleration Time & External Inertia.



t [sec] - Decelerations time.
V [Krpm] - Speed.
T [Nm] - Torque.
J [kg*m²] - External Inertia.

T1=2.13 [N*m] - Peak Torque.
T2=0.302 [N*m] - Continuous Stall Torque.
T3=0.192 [N*m] - RMS Torque.

Air Flow Vs. Air Pressure



CONDITION

1. Ambient Temperature - 22 [°C],24 [°C]
2. No Rotation.
3. Inlet pipe diameter D=4 mm.
4. Inlet pipe length L=1500 mm.
5. No tool holder.
6. Including brushes.
7. Air outlet ventilated.
8. Flowting Point - 2 bar.

Inlet Air Flow.

$$F_{AI}=21.864*P_{AI}^{0.461}$$

Pai [bar] *-Inlet Air Pressure.*
Fai [LPM] *- Inlet Air Flow.*

Sensor Ventilation Air Flow.

$$F_{BV}=8.471*e^{0.241*P_{AI}}$$

Pai [bar] *- Inlet Air Pressure.*
Fbv [LPM] *- Air Flow in Sensor Ventilation.*

Outlet Air Flow

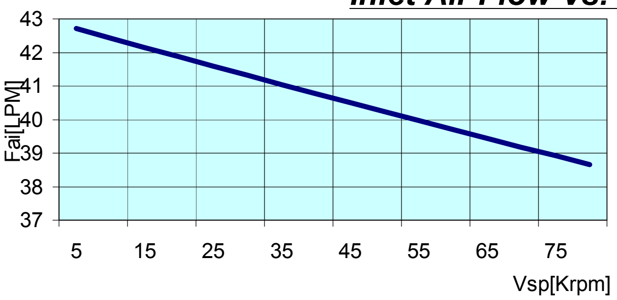
$$F_{AO}=5.75*e^{0.198*P_{AI}}$$

Pai [bar] *- Inlet Air Pressure.*
Fao [LPM] *- Air Flow in spindle exit.*

CONDITION

1. Pipe diameter at checking point D=4 mm.
2. Pipe length at checking point L=1000 mm.

Inlet Air Flow Vs. Rotation Speed.



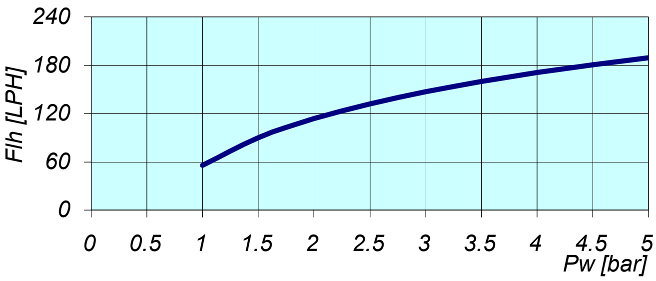
$$F_{AI} = 43*e^{(-0.0013V_{SP})}$$

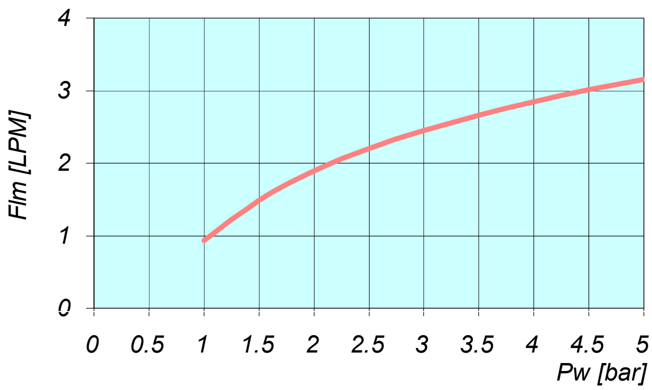
Vsp [Krpm] *- Rotation Speed*
Fai [LPM] *- Inlet Air Flow*

CONDITION

1. Ambient Temperature - 22 [°C],24 [°C]
2. Ambient Humidity 60%.
3. Including sensor brushes.
4. Entry pressure Pai = 5 [bar].

Water Flow Vs. Water Pressure





Flow=α+β*ln(Pressure)

Flow @ LPH α=56, β=83
Flh=56+83*ln(Pw)

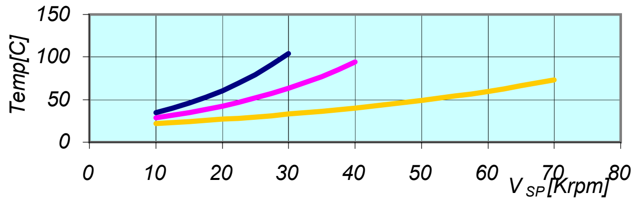
Flow @ LPM α=0.9, β=1.4
Flm=0.9+1.4*ln(Pw)

Pw[bar] - Water Pressure
Flh[LPH] - Water Flow in L/H
Flm[LPM] - Water Flow in L/M

CONDITION

1. Water Temperature - 18 [°C],20 [°C]
2. Room Temperature - 22 [°C],24 [°C]
3. No Rotation.

Motors Temperature Vs. Rotation Speed & Cooling System



$Temp = a*e^{b*Vsp}$
$T_W = 18*e^{0.02*V_{SP}}$
$T_A = 19*e^{0.04*V_{SP}}$
$T_{SA} = 20*e^{0.055*V_{SP}}$

Temp [° C] - Motor temperature
Vsp [Krpm] - Speed rotation

CONDITION

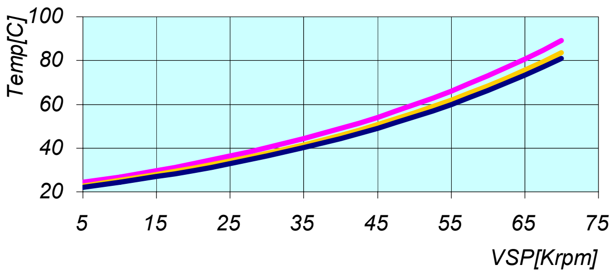
1. General.
No tool holder (wheel mount).
Including sensor.
Ambient Temperature 22-24 [°C].
Temp. Measurement - termistor.

2. Still air cooling.

3. Air flow cooling.
Air Flow 40 LPM.
Air Pressure 5 bar.

4. Water flow cooling.
Water Temperature 12 [°C].
Water Pressure 5 bar.
Cooling Water Flow 3.2 LPM.

Motor Temperature Vs. Water Pressure



P_1=1bar **P_2=3 bar** **P_3=5bar**

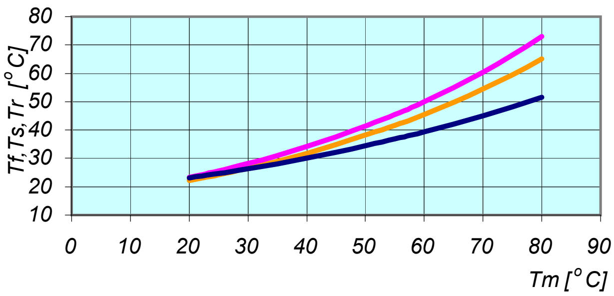
$T=22*P_W^{(-0.06)}*e^{0.02*V_{SP}}$

Vsp [Krpm] - Speed rotation
Pw[bar] - Water Pressure
Tm [° C] - Motor temperature.

CONDITION

1. Driver - BDH - Hathaway.
2. Ambient Temperature 22-24 [°C].
3. Ambient Humidity 60%.
4. Temp. Measurement termistor - SEMITEC 203GT-1.

The Spindle Thermal Behavior



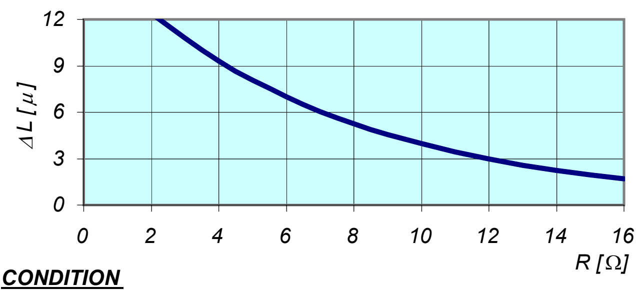
$Ts = 15.92*e^{0.019*Tm}$
$Tf = 15.487*e^{0.018*Tm}$
$Tr = 17.58*e^{0.013*Tm}$

Tm [° C] - Motor temperature.
Tf [° C] - Temperature in the front area.
Ts [° C] - Temperature in the middle area.
Tr [° C] - Temperature in the rear area.

CONDITION

1. No cooling.
2. Ambient Temperature 22-24 [°C].
3. Ambient Humidity 60%.
4. Air Pressure in entrance 5 bar.

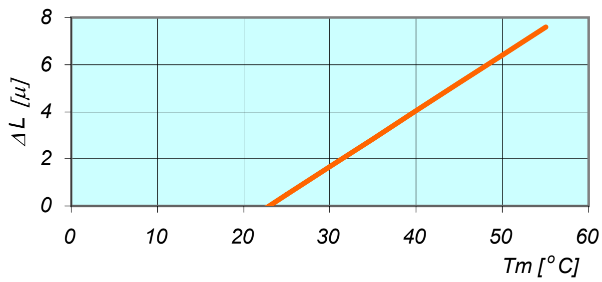
Shaft Extension Vs. Thermistor Resistance



CONDITION

1. Ambient Temperature 22-24 [°C].
2. End shaft extension.
3. Reaction time for temperature stabilization in shaft ~ 5 min.

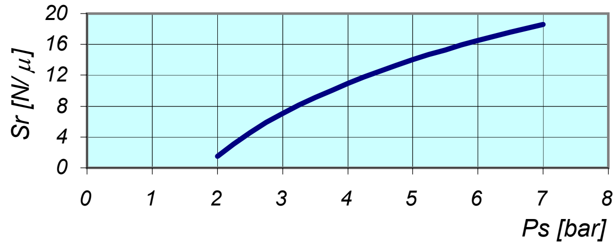
Shaft Extension Vs. Motor Temp



$\Delta L = 0.236*Tm-5.426$
$\Delta L= 16.442*e^{-0.142*Rmotor}$

ΔL[μ] - Shaft extension
R[Ω] - Termistor resistance
Tm [° C] - Motor temperature

Radial Stiffness Vs. Air Pressure

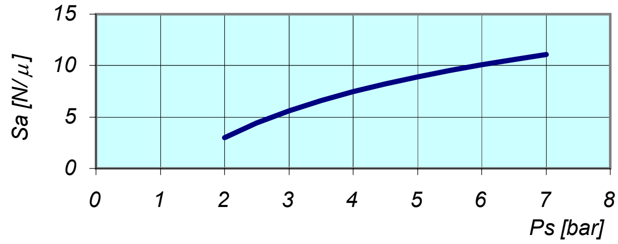


Sr=13.642*ln(Ps)-7.956
Theoretical curves

Ps [bar] - Spindle air pressure.
Sr [N/μ] - Radial Stiffness.

CONDITION
1. No Rotation.
2. Distance Form The End of The Spindle - 18mm

Axial Stiffness Vs. Air Pressure

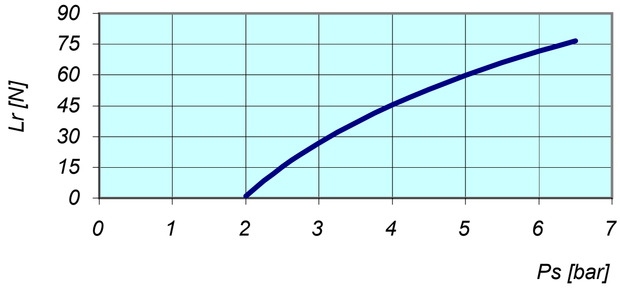


Sa=6.425*ln(Ps)-1.454
Theoretical curves

Ps [bar] - Spindle air pressure.
Sa [N/μ] - Axial Stiffness.

CONDITION
1. No Rotation.

Radial Load Capacity Vs. Air Pressure

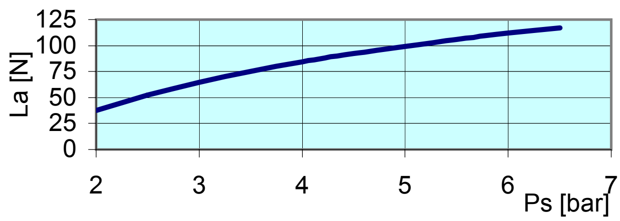


Lr=64.39*ln(Ps)-43.832
Theoretical curves

Ps [bar] - Spindle air pressure.
Lr [N] - Radial load capacity.
2. Distance Form The End of The Spindle - 18mm

CONDITION
1. No Rotation.

Axial Load Capacity Vs. Air Pressure

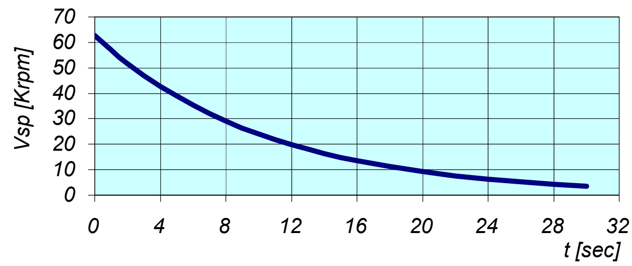


La=67.664*ln(Ps)-9.4
Theoretical curves

Ps [bar] - Spindle air pressure.
La [N] - Axial load capacity.

CONDITION
1. No Rotation.

No Load Deceleration

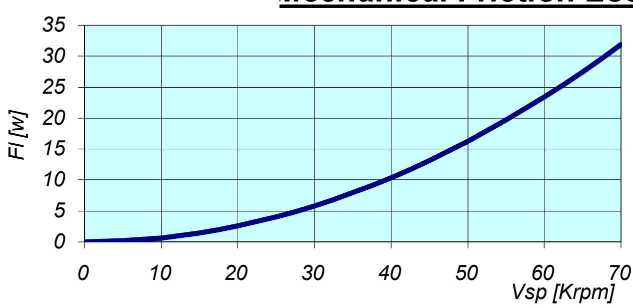


$Vsp = 62.7*e^{-0.096*t}$

t [sec] - Deceleration time.
Vsp [Krpm] - Speed in "t" time

CONDITION
1. Ambient temperature 22°C.
2. Water cooling.
3. No external mechanical load.
4. Air pressure at entrance - 5 bar.

Mechanical Friction Losses

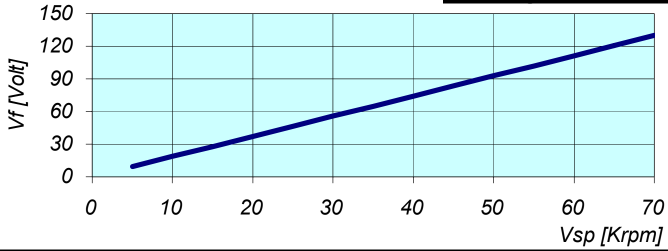


$F_L = 6.5*10^{-3}*V_{SP}^2$

FL [w] - Friction Loss.
Vsp [Krpm] - Spinning Speed.

CONDITION
1. No external mechanical load.
2. Ambient temperature 22°C.
3. Air pressure - 5 bar.

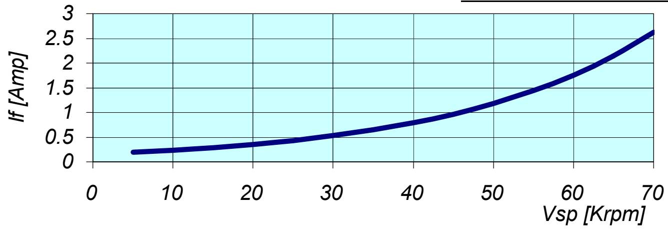
Voltage Constant (BEMF)



$$V_f = 1.854*V_{sp}$$

Vsp [Krpm] - Rotation Speed
Vf [Volt] - Voltage between two phases.

Current Vs. Rotation Speed



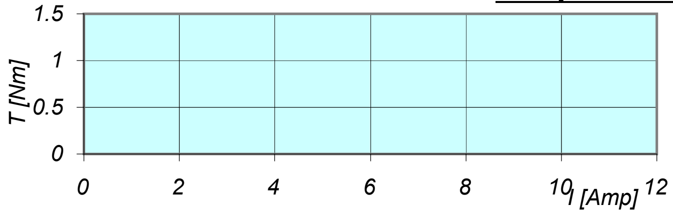
$$I_f = 0.159*e^{0.04*Vsp}$$

If [Amp] - Current Phases.
Vsp [Krpm] - Rotation Speed.

CONDITION

1. Driver - BDH - Hathaway.
2. No external load.
3. Including Sensor Brushes.
4. No tool holder.
5. Humidity - 50%.
6. Ambient temperature 22-24 [˘ C].

Torque Vs. Current

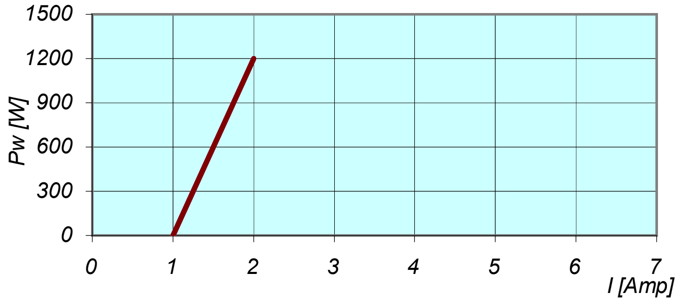


$$T = 0.018*I$$

Kt = 0.018 Nm/Amp

T [Nm] - Spindle Torque.
I [Amp] - Current.
Kt [Nm/Amp] - Torque Sensitivity.

Power Vs. Current & Rotation Speed

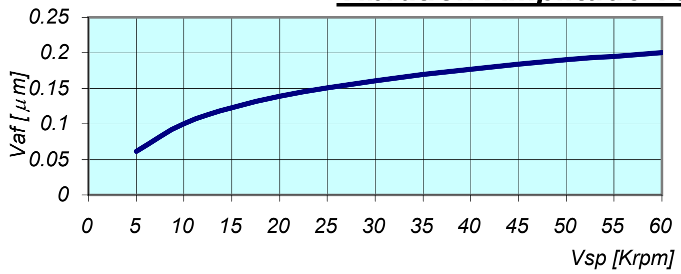


$$P = 18*I*Vsp$$

I [Amp] - Current.
Vsp [Krpm] - Rotation Speed
Pw [W] - Power.

V=1Krpm **V=2Krpm** **V=3Krpm**
V=4Krpm **V=5Krpm** **V=6Krpm**

Vibration Amplitude Vs. Rotation Speed



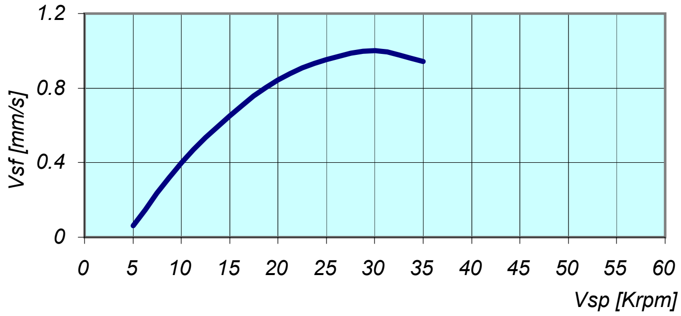
$$V_{af}=0.056*\ln(V_{sp})-0.03$$

Vaf [μm] - Vibration Amplitude.
Vsp [Krpm] - Rotation Speed.

CONDITION

1. Peek to Peek.

Vibration Speed Vs. Rotation Speed



$$V_{sf}=-7.5*10^{-5}*V_{sp}^{2}+4.5*10^{-3}*Vsp-17.5*10^{-3}$$

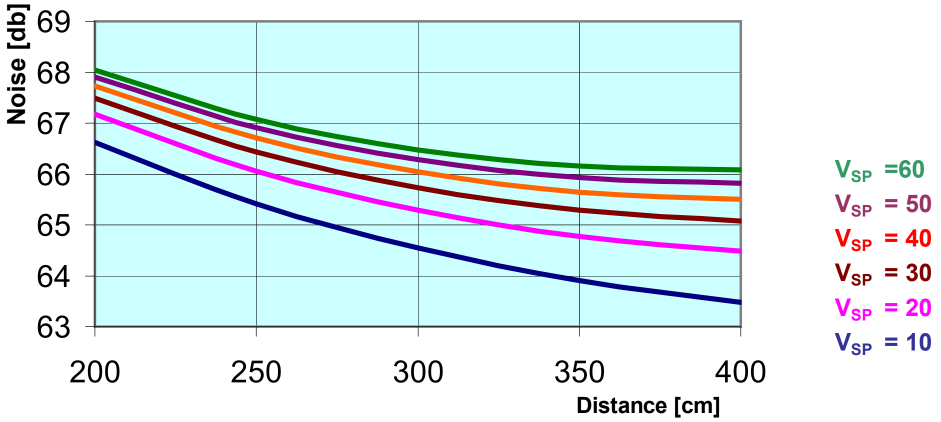
Vsp < 30 Krpm

$$V_{sf}=0.15-0.029*\ln(V_{sp})$$

Vsp > 30 Krpm

Vsf [mm/s] - Vibration Speed.
Vsp [Krpm] - Rotation Speed.

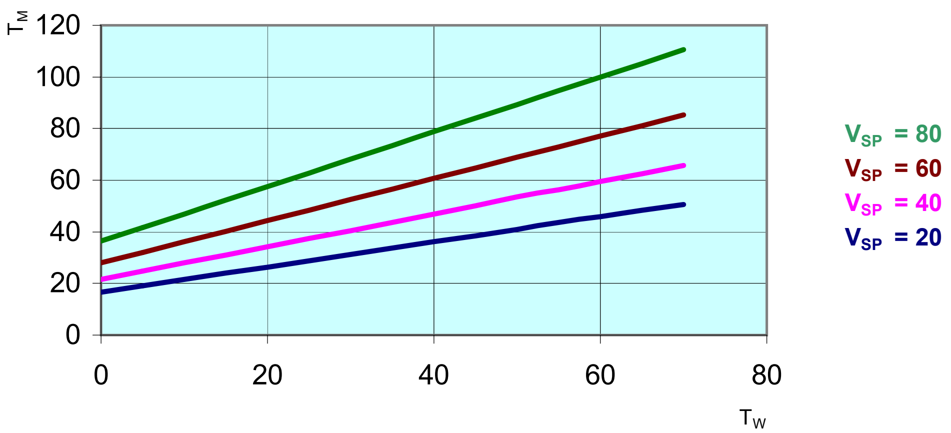
Noise Level [db]



$$\boxed{L_P = 100.3-6.7*\ln(D)+0.44*e^{(0.003*D)}*\ln(V_{SP})}$$

V_{SP} [Krpm] - Rotation Speed
N [dB] - Noise Level
D [cm] - Length from Spindle

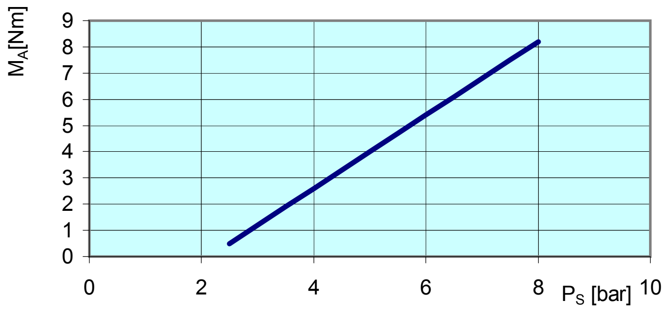
Motor Temperature Vs Rotation Speed & Water Temperature



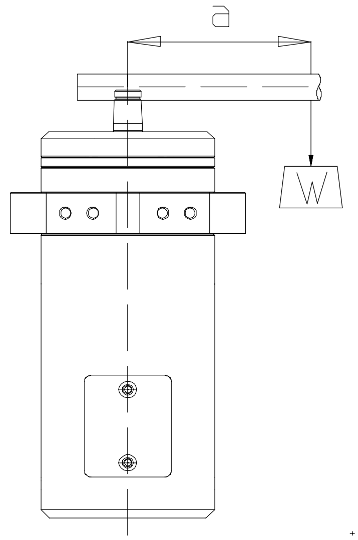
$$\boxed{T_M = 0.457*(28.1+0.82*T_W)*e^{0.013*v_{sp}}}$$

[C] T_M = Motor Temperature
[C] T_W = Water Temperature
[Krpm] V_{SP} = Rotation speed

Moment Vs. Air Pressure

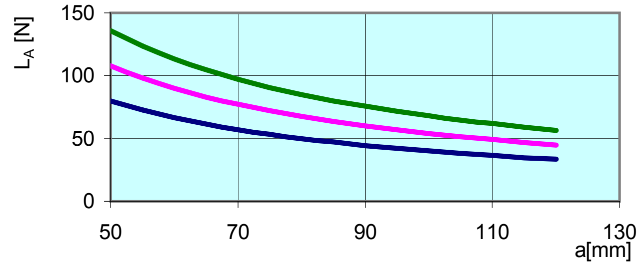


$$\boxed{M_A = 1.4*P_S - 3}$$



[Nm] M_A = Axial Moment
[bar] P_S = Spindle Air Presuure

Load Vs. Axis Length & Air Press'

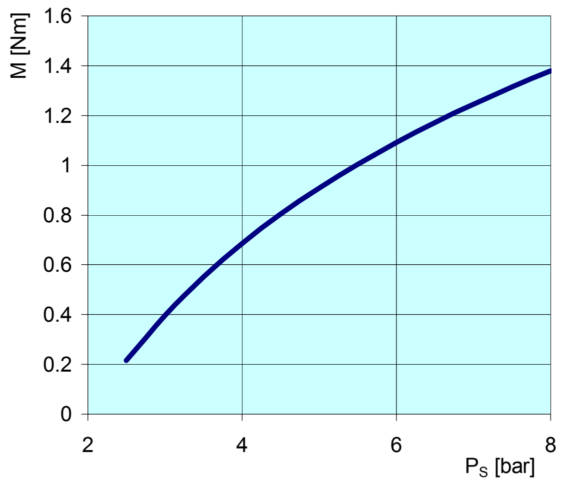


P_S = 7
P_S = 6
P_S = 5

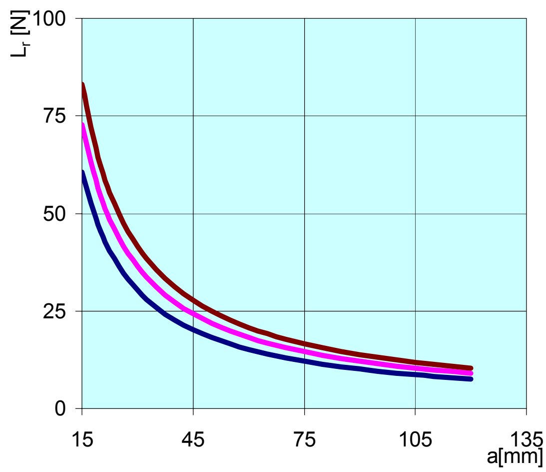
$$\boxed{L_A = 10^3[1.4*P_S-3]*a^{-1}}$$

[N] L_A = Axial Load
[bar] P_S = Spindle Air Press'
[mm] a= Length From the Axies

Moment Vs. Air Pressure



Load Vs. Length & Air Pressure



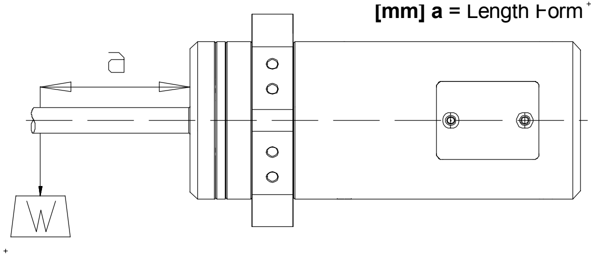
P_S =5 P_S =6 P_S =7

$$\boxed{M_r = \ln(P_S) - 0.7}$$

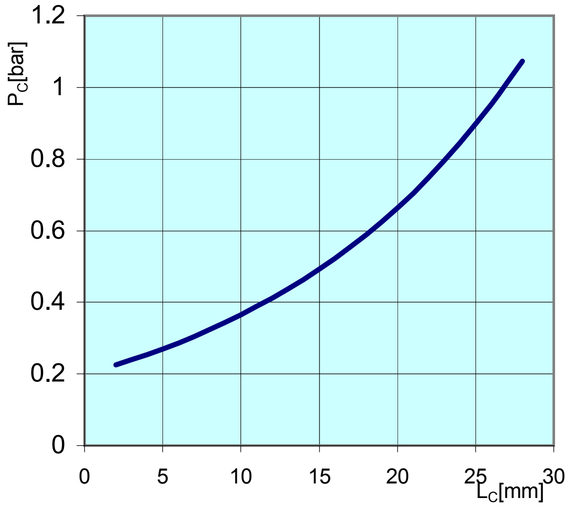
$$\boxed{L_r = 100[10*\ln(P_S) - 7]*a^{-1}}$$

[Nm] M_r = Radial Moment
[bar] P_S = Spindle Air Press'

[N] L_r = Radial Load
[bar] P_S = Spindle Air Press'
[mm] a = Length Form Spindle's End.



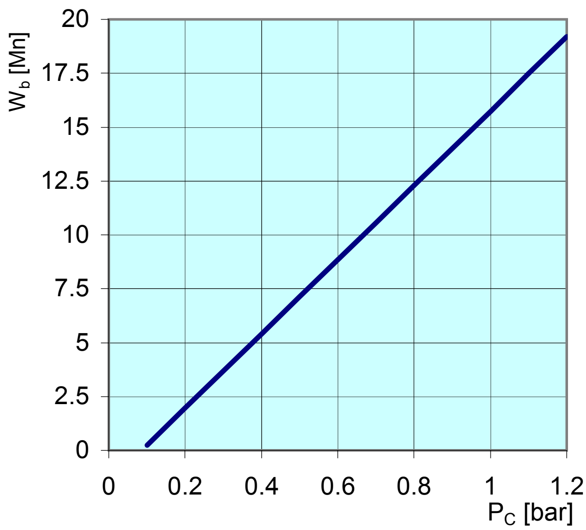
Brushes Press' Vs. Length



$$P_C = 0.2*e^{0.06*L_C}$$

[bar] P_C = Brushes Pressure
[mm] L_C = Brushes Length

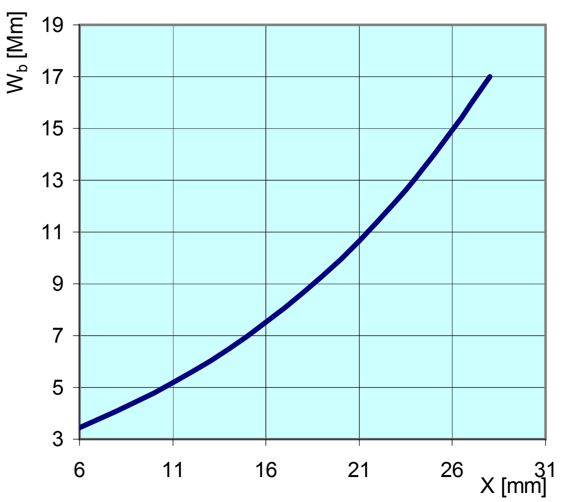
Brushes Wear Vs. Pressure



$$W_B = 17.24*P_C-1.5$$

[Mm] W_b = Brushes Wear
[bar] P_C = Brushes Pressure

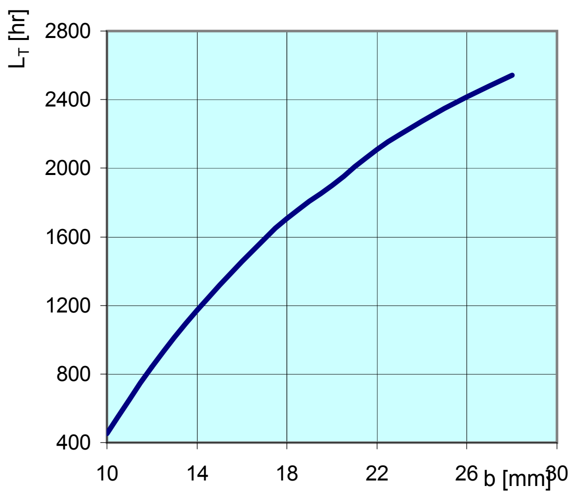
Brushes Wear Vs. Length



$$W_B = 3.45*e^{0.06x}-1.5$$

[Mm] W_b = Brushes Wear
[mm] X = Brushes Length

Brushes Lifetime Vs. Length



$$\int_a^b \left(\frac{1000}{3.45*e^{0.06x}-1.5} \right) dx$$

$$L_t = 2045.45*\ln(b)-4230.57$$

[mm]b = Final Length
[mm] a = Primery Length
[mm] X = Brushes Length
[hr] L_t = Brushes Life-Time

Condition :Initial Pressure = 0.9bar @ 28mm

Raw Materials Data

The Spindle is made from the following materials:

Stainless steel: SAE 303,
SAE 2316.
Brass SAE 40, Copper.

Polymers: Delerin

Chemical composition							
SAE 303		**SAE 2316**		**BRASS SAE 40**		**COPPER Cu**	
%C	0.15	%C	0.34	%Cu	58.1	%Cu	99.96
%Si	1	%Si	0.16	%Pb	2.83	%Pb	0-8
%MN	2	%MN	0.88	%Al	0.01	%Bi	0-1
%P	0.2	%P	0.025	%Fe	0.29		
%S	0.15-0.4	%S	0.003	%Ni	0.1		
%CR	17-19	%CR	15.12	%Sn	0.24		
%MO	0.6	%MO	0.91				
%Ni	8--10	%Ni	0.53				

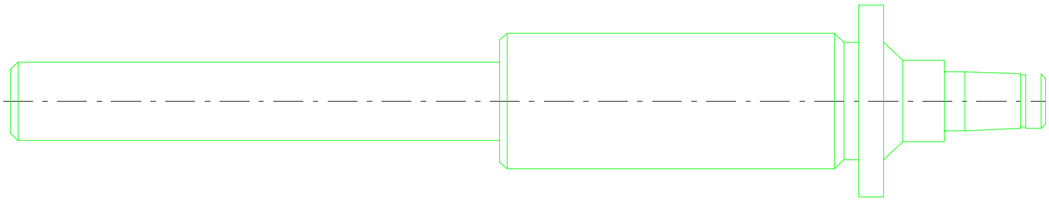
Mechanical properties		
	SAE 303	**SAE 2316**
Hardness HB	262	235
0.2% proof stress N/mm2	190	
0.1% proof stress N/mm2	225	
Tensile strength N/mm2	500-750	
Elongation (L=5d) % min	35	
Core strength N/mm2		900-1100
Modulus of elasticity 103 N/mm2		223
Density kg/dm3	7.9	7.7
Thermal conductivity W/(m.K)	15	15
Electric resistivity Ohm.mm2/m	0.73	0.8
Specific heat capacity J/(kg.K)	500	430

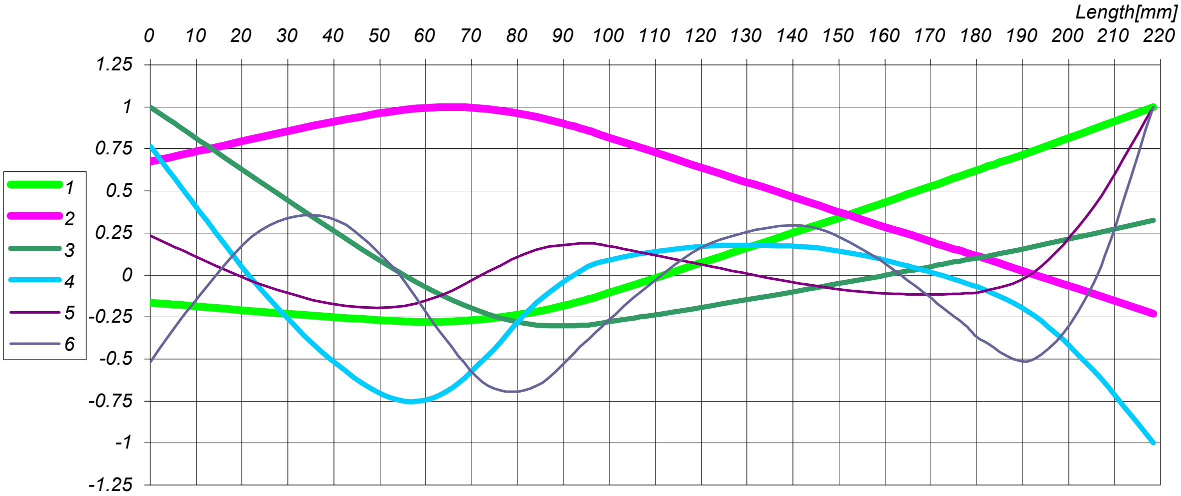
Mechanical properties		
	BRASS SAE 40	COPPER Cu
Tensile strength N/mm2	310	257
Elongation (L=5d) % min	30	24
Hardness HB	80	83

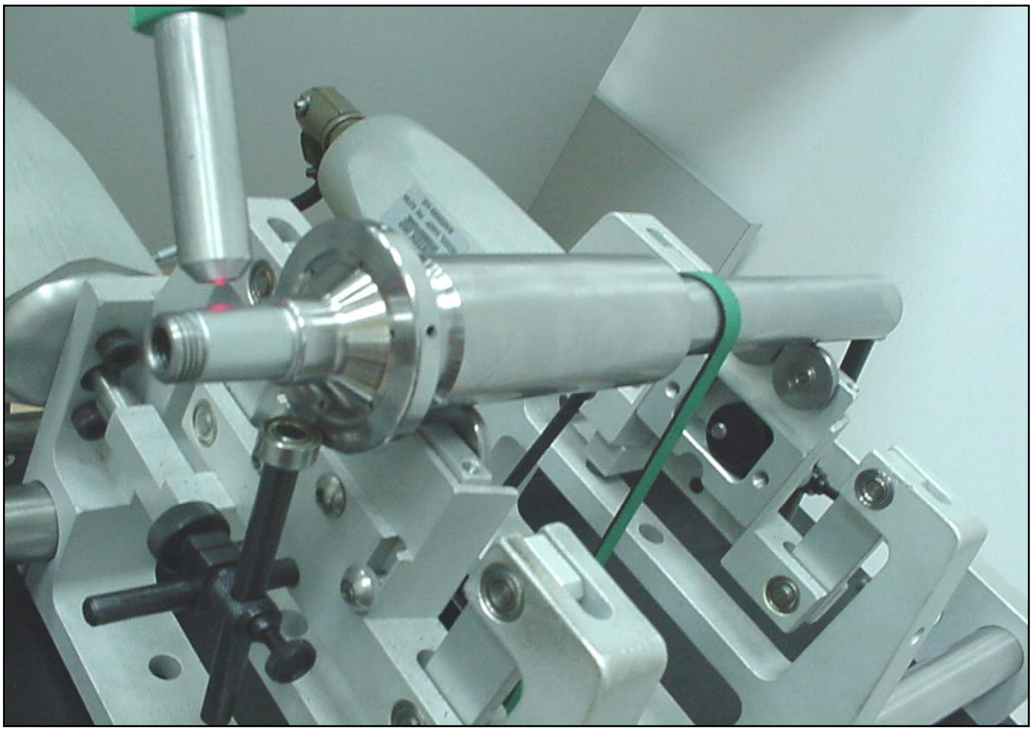
Corresponding standard	
SAE 303	**SAE 2316**
Din 1.4305	Din 1.2316
X8CrNiS18-9	X36CrMo17
Z10CNF1809	Z35CD17
S30300	THYROPLAST 2316

Typical properties			
Silver graphite		**Delerin**	
Item	SX-70	Density	1.43
Buik density g/cm3	4.45	Tensile strength, kg/cm2	660
Hardness	15	Pressure strength, kg/cm2	600
Specific resistivity m W*m	0.25	Flexural strength, kg/cm2	1000
Flexural atrength Mpa	40	Modle hardness, kg/cm2	27000
Paripheral speed (MAX), m/sec	20	Elongation, %	25
Current density (MAX), A/cm2	15	Hardness	R120
		Abrasion mg less for 1000 revolu	20

SPINDLE MODES







SPINDLE BALANCING

Why is balancing important?

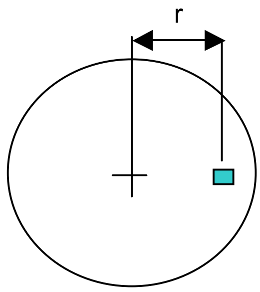
Force ***(F)*** generated by unbalance can be calculated from formula:

$$F(Kg) = 0.001 \times (gmm) \times (RPM/1000)^2$$

$$F(Kg) = 0.001 \times (w \times r) \times (RPM/1000)^2$$

where ***w*** = Unbalance weight in grams

r = Radius in millimetres



Effects of Unbalance

Reduced component life.

Bearings, seals, windings, rotor bars, foundations, supports.

Impaired clearancs / tolerances.

Component displacement, Reactive misalighment.

Resonance.

Flexing of critical speed rotors.

Excessive vibration and noise

Health / safety considerations

Poor product quality.

Diagnosing Unbalance

Vibration frequency equals rotor speed.

Vibration predominantly RADIAL in direction.

Stable vibration phase measurement.

Vibration phase shifts in direct proportion to measurement direction.

Causes of unbalance

Rotor not mass centred geometrically

- Machining / casting inaccuracioes.
- Fitting / assembly tolerance inaccuracies.

Uneven mass distribution

- Windings / commutator segments.
- Blow holes / inclusions in castings.
- Component mismatch.
- Keys / keyways.

Causes of unbalance

Service effects

Thermal dimensional changes:

- Stress relieving.
- Uneven thermal growth.
- Thermal displacement / loosening of components.

Displacement / settling of components:

- Windings Impellers Fan side plates.

Deposit build-up / Erosion / corrosion.

Rotor flexibility

Forced whip.

critical speed deflection.

Induced by other forces

Aerodynamic.

Hydraulic.

Electrical.

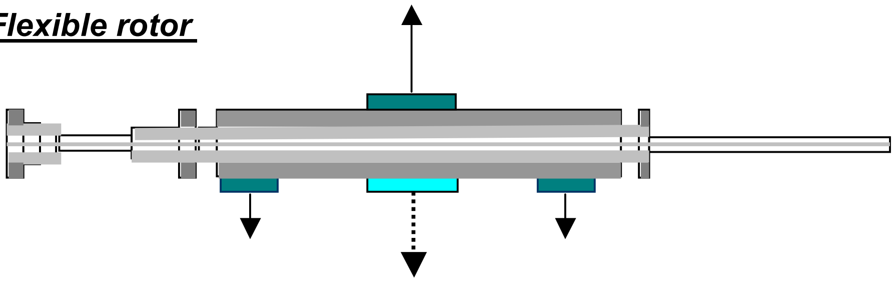
Rigid Rotors

Maximum operating speed below 70% of natural frequency or first critical speed.
Can be balanced at any speed:

> ***Will remain in balance throughout speed range provided tolerance, calculated to maximum service speed, is achieved.***
> ***tolerance, calculated to maximum service speed, is achieved.***

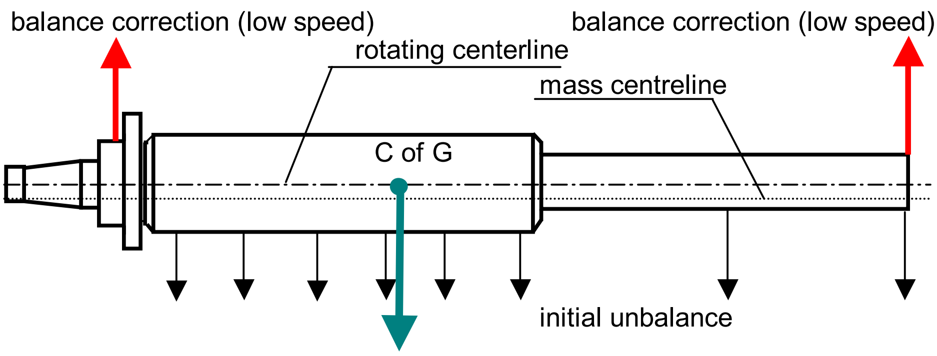
Balance corrections made in any two arbitrary correction planes.

Flexible rotor

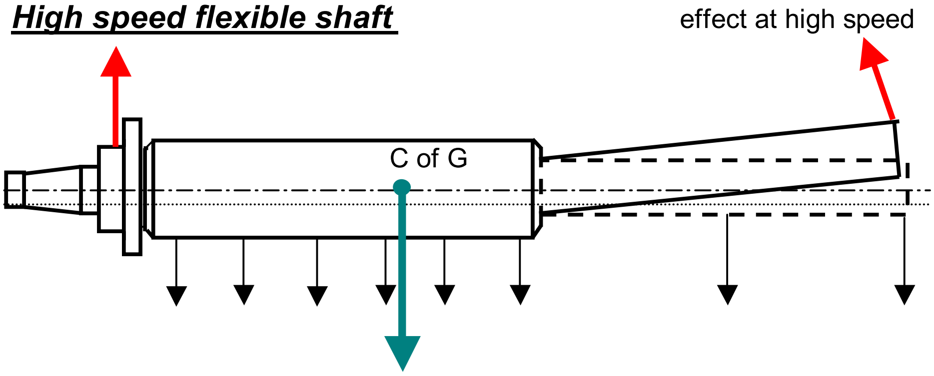


Does not satisfy the definition of a rigid rotor and has a tendency to bend or distort due to centrifugal and unbalance forces

High speed flexible shaft



High speed flexible shaft



Correcting Unbalance

In-situ balancing is best.
In-situ balancing is not always possible.

Balance Tolerances

Manufacturers' recommendation.
International standards ISO 1940/1.

In-Situ Requirements

Unbalance is primary problem.
Access to add / remove weight.
Ability to start / stop machine "at will"

ISO 1940/1 has also been adopted by:
BS 6861 Part 1 (British Standards)
ANSI S 2.19-1975 (American National Standards Institute)
VDI 2060 (German Standards)

ISO Rotor Classifications

GO.4

Spindles, precision grinders, Gyroscopes.

G1

Small special purpose electrical rotors / drives.

G2.5

Gas / steam turbines, Turbo compressors, machine tool drives. Small and special purpose electric rotors.

G6.3

Fans, Pump impellers, general electric rotos, centrifuge drums, general machinery parts.

Balance Tolerances

ISO 1940 / 1

$$MCD\ (e\,\mu m) = \frac{G \times 1000}{2\pi n/60} = \frac{9549 \times G}{n}$$

Where:

G - Balance quality grade

n - Max rotor seryice speed

Uper (gmm) = e per.W

$$Uper\ (gmm) = \frac{9549 \times G}{n} \times W$$

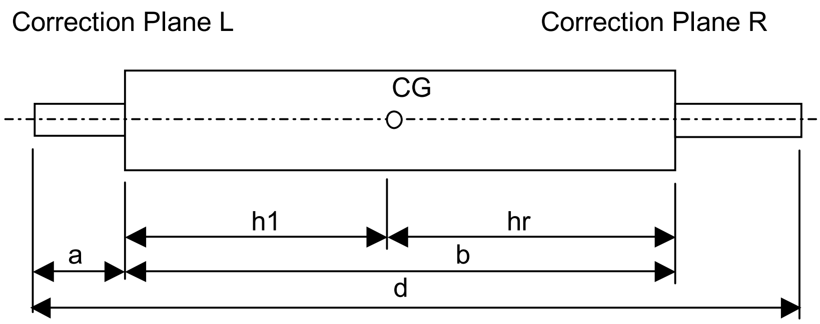
Where:

G - Balance quality grade

W - Weight of Rotor in kilograms

n - Max rotor service speed in RPM

Symmetrical Rotors



Rules for Symmetrical Rotors

1. Correction Planes are between bearings.
2. Distance "b" is greater than 1/3 "d".
3. Correction plane are equidistant from the center of gravity.

Balance tolerance per Plane = Uper/2.

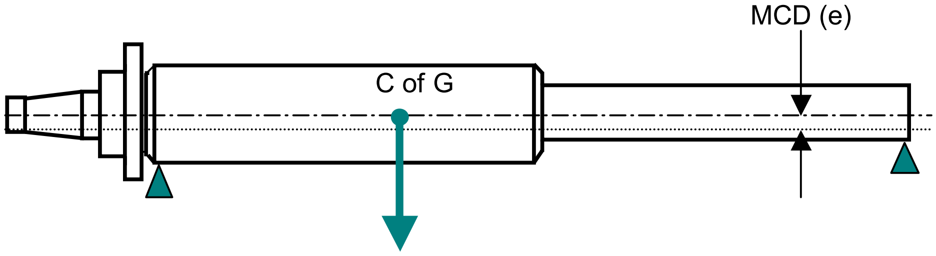
When correction planes are ***NOT*** equidistant from the center of gravity:

Uper Left = Uper (hR/b)

Uper Right = Uper (hL/b)

The Uper Left or Right should not be less than 30% or more then 70% Uper. If they are then use the rules for narrow plane rotors.

Applying ISO 1940 on Aerostatics Spindle @ G0.4



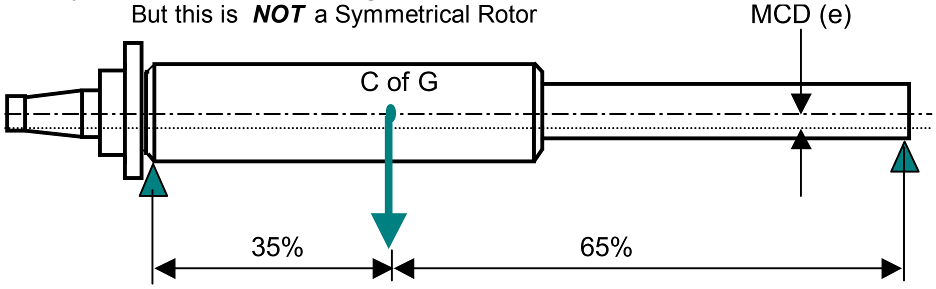
Service speed: 80000 rpm
Weight: 700 grams
Balance quality: G0.4

MCD (e) μm = 9549 G/n

MCD (e) μm = 9549 x 0.4/80000 = ***0.048*** μm

So Permissible Unbalance (U per) = 0.048 µm x 0.7 kg
So Permissible Unbalance (U per) = ***0.034 gmm TOTAL***
Permissible Unbalance (Uper) at C of G = ***0.034 gmm*** TOTAL
For Symmetrical Rotor = ***0.017 gmm*** Per Plane

But this is ***NOT*** a Symmetrical Rotor



Left plane radius: 15 mm
Right plane radius: 9.5 mm

Permissible Unbalance (Uper) = ***0.034 gmm TOTAL***

Uper ***Left*** = 0.034 x 65% = 0.022 gmm = ***0.0015 g @ 15 mm***
Uper ***Right*** = 0.034 x 35% = 0.012 gmm = ***0.0013 g @ 9.5 mm***

Applying ISO 1940 on Aerostatics Spindle @ G1

Service speed: 80000 rpm
Weight: 700 grams
Balance quality: G1

MCD (e) μm = 9549 G/n

MCD (e) μm = 9549 x 1/80000 = ***0.12*** μm

So Permissible Unbalance (U per) = 0.12 µm x 0.7 kg
So Permissible Unbalance (U per) = ***0.084 gmm TOTAL***
Permissible Unbalance (Uper) at C of G = ***0.084 gmm*** TOTAL
For Symmetrical Rotor = ***0.042 gmm*** Per Plane

But this is ***NOT*** a Symmetrical Rotor

Left plane radius: 15 mm
Right plane radius: 9.5 mm

Permissible Unbalance (Uper) = ***0.084 gmm TOTAL***

Uper ***Left*** = 0.084 x 65% = 0.055 gmm = ***0.0036 g @ 15 mm***
Uper ***Right*** = 0.084 x 35% = 0.03 gmm = ***0.003 g @ 9.5 mm***

ELECTRICAL SYSTEM

Electricity - Electrical flow for frequency converter.
Warranty will be granted only when using the original driver that we supplied.

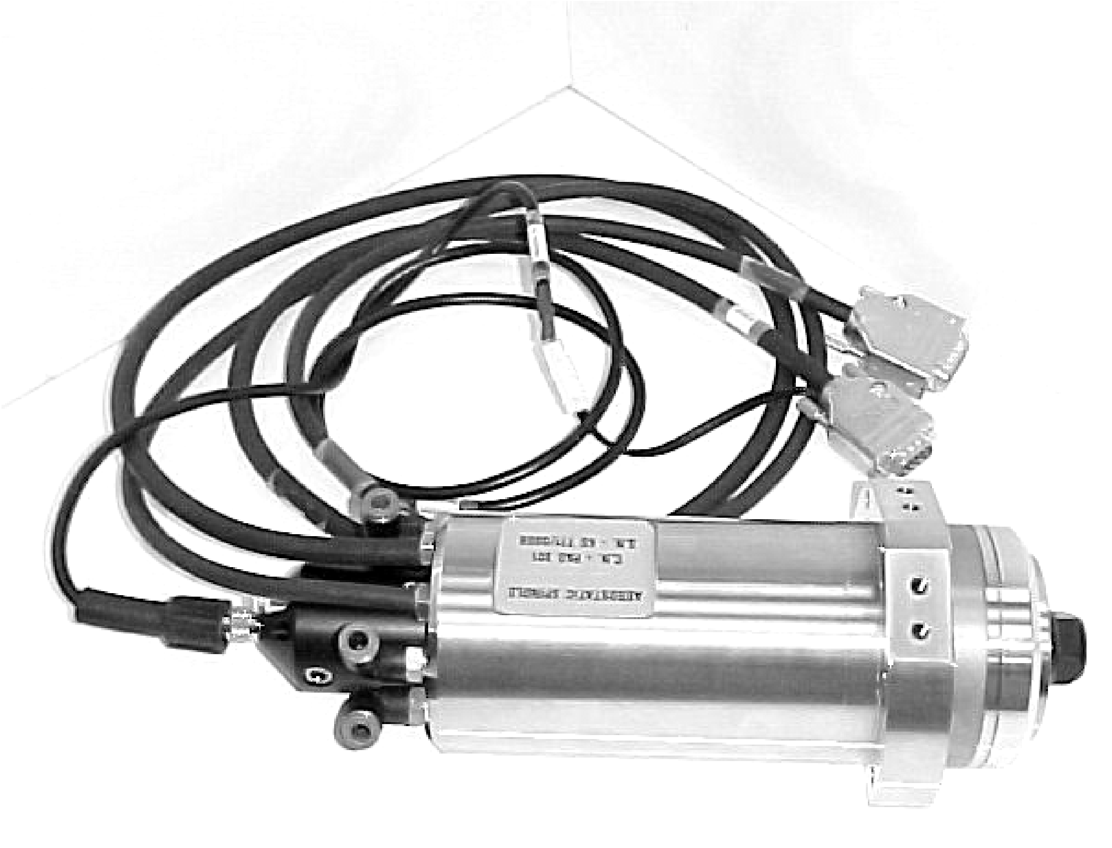
The electricity connection is done with fittings.

Connect the cables according to their marks:

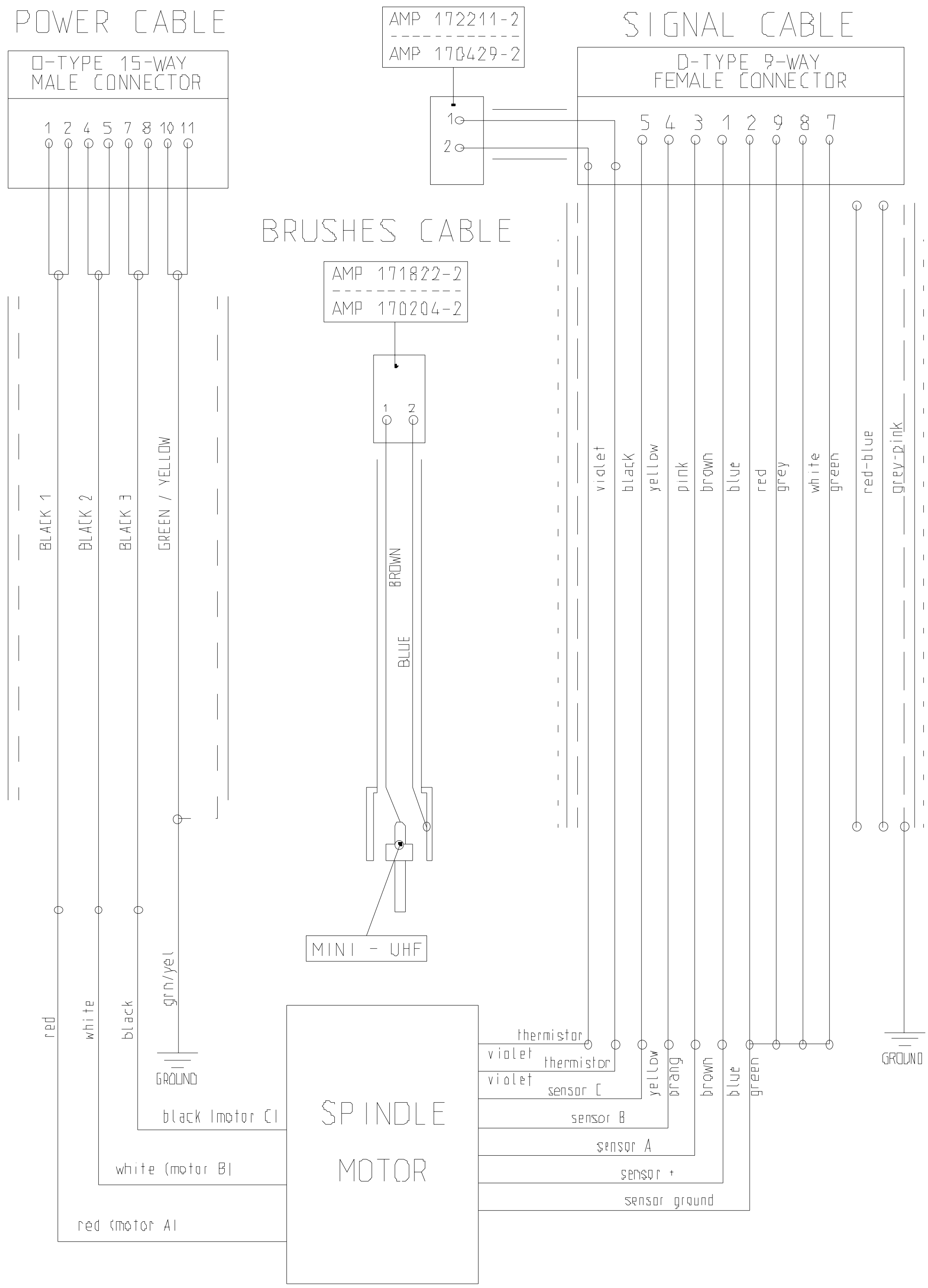
Power Cable - marked “power” with a D-type 15 pin plug.
Signal Cable - marked “signal” with D-type 9 pin plug + plastic socket with 2 pins for thermistor.
Brushes cable - marked “brushes” with a mini UHP inlet for connecting the spindle, and 2 plastic pins for connecting the sensors.

The spindle has a unique sensor system built in using 2 brushes attached to the shaft by air pressure. The coals wear out with time and their life span shortens.

The purpose of the brushes is to transfer the electricity from the control system through the shaft through the machine-base back to the controller.
This system is able to perform calibration of the height shaft.



ELECTRICAL CONNECTIONS



THERMISTOR

"Thermistor" is the generic name given to thermally sensitive resistors. Negative temperature coefficient thermistor is generally called as thermistor. Thermistor is a semi conducting ceramic resistor produced by sintering the materials at high temperature and made mainly from metal oxide. Depending on the manufacturing method and the structure, there are many shapes and characteristics for various purposes such as temperature measurement, temperature compensation etc.

Temp2 [°C] @ Rst2 [KΩ]   2 ~ 40
$Temp2 = 95.512 - 23.47 * \ln(Rst)$

Temp1 [°C] @ Rst2 [KΩ]   0 ~ 70
$Temp1 = 110.139 - 28.929 * \ln(Rst)$

Rst2 [KΩ] @ Temp [°C]   10~80
$Rst2 = 58.189\, e^{(-0.042Temp)}$

Rst1 [KΩ] @ Temp [°C]   0~180
$Rst1 = 48.881\, e^{(-0.037Temp)}$

Rst - Thermistor resistant as function at temperature
Temp- Electric motor temperature

203GT-1

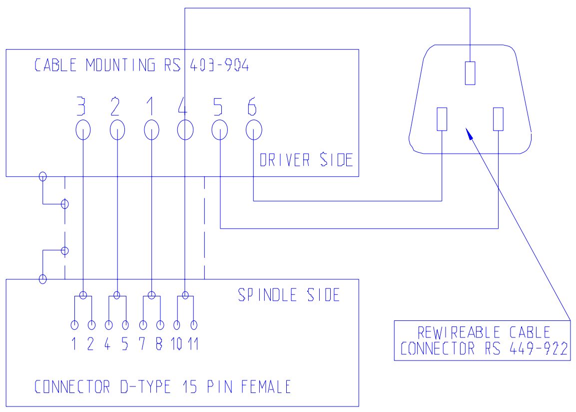
TEMPERATURE VS RESISTANCE CHA[illegible]

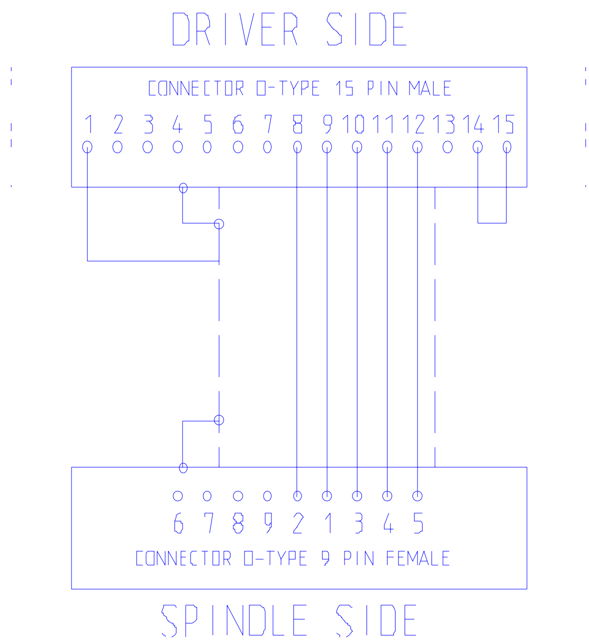
SEMITEC®

Resistance 20kΩ at 25°C
Resistance Tolerance ±3 %
B Value 4282K at 25/85 °C
B Value Tolerance ± 2 %

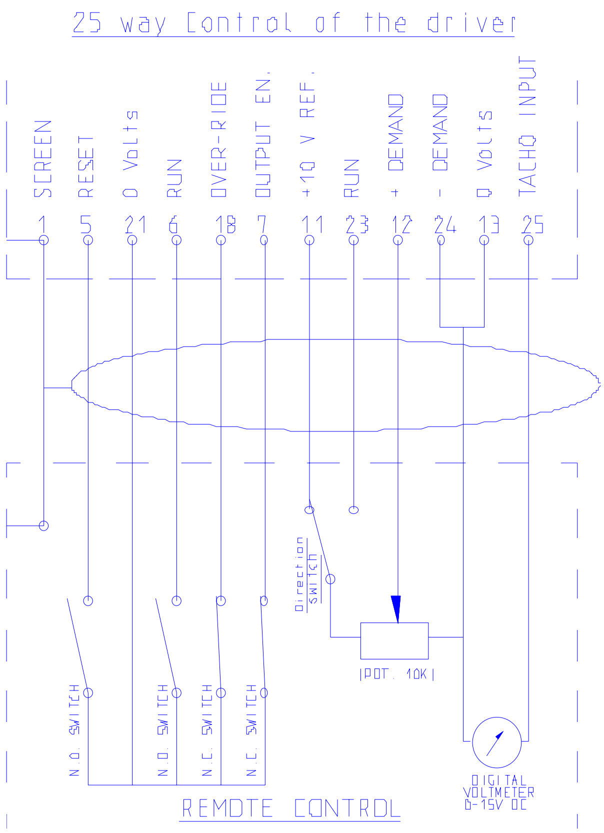
Temp. (°C)	Rmax. (kΩ)	Rst. (kΩ)	Rmin. (kΩ)	Tolerance (°C)	
-50	2144	1901	1683	-1.6	+1.6
-40	1011	909.0	816.9	-1.5	+1.5
-30	496.9	453.2	413.0	-1.4	+1.4
-20	256.1	236.6	218.4	-1.3	+1.3
-10	137.2	128.3	119.9	-1.2	+1.2
0	76.43	72.32	68.37	-1.0	+1.1
10	44.16	42.24	40.36	-0.9	+0.9
20	26.36	25.47	24.58	-0.7	+0.8
30	16.37	15.82	15.27	-0.8	+0.8
40	10.55	10.10	9.663	-1.0	+1.1
50	6.971	6.620	6.280	-1.3	+1.3
60	4.717	4.444	4.182	-1.6	+1.6
70	3.262	3.050	2.849	-1.9	+1.9
80	2.303	2.138	1.982	-2.2	+2.2
90	1.656	1.527	1.407	-2.5	+2.6
100	1.212	1.111	1.016	-2.8	+2.9
110	0.9013	0.8209	0.7469	-3.2	+3.3
120	0.6802	0.6160	0.5573	-3.6	+3.7
130	0.5203	0.4686	0.4217	-3.9	+4.0
140	0.4033	0.3613	0.3234	-4.3	+4.5
150	0.3163	0.2820	0.2511	-4.7	+4.9
160	0.2509	0.2226	0.1973	-5.2	+5.3
170	0.2011	0.1777	0.1568	-5.6	+5.8
180	0.1629	0.1432	0.1258	-6.1	+6.3
190	0.1331	0.1166	0.1020	-6.5	+6.8
200	0.1097	0.09573	0.08345	-7.0	+7.3
210	0.09122	0.07929	0.06885	-7.5	+7.8
220	0.07644	0.06620	0.05728	-8.1	+8.4
230	0.06453	0.05570	0.04803	-8.6	+9.0
240	0.05489	0.04722	0.04058	-9.2	+9.6
250	0.04700	0.04030	0.03452	-9.8	+10.2

ADAPTOR FOR POWER CABLE AND SIGNAL CABLE





REMOTE CONTROL



DESCRIPTION OF A SPINDLE TESTING.

Introduction:

After connecting the spindle to the computerized testing system (air, electricity, control etc.), it will automatically perform a series of tests, record the results, send notice when the test fails and stop in case of danger. At the end of each test a detailed report is received including diagrams.

- You can change the numeric definitions for the operating process.
- Results recording will be continuous and written in data format. In case of a failure data will be recorded for the propose of repairing the defects (faults) As well as reference and proposals for improving.
- When a test will fail, a window will open with the name of the test blinking.
- A test report will be produced at the end of the test.
- On the screen there will be a display of the test progress, a graphic display, and a analogy of digital display

Connecting The Spindle To The Testing System

Identify the spindle (serial number, bar code etc.)
- Connect inlet and outlet water tubes do the same with air tube.
- Connect ventilation tube.
-Connect pressure measuring sensors tube (rather then a screw)
-Connect cables in the following order: sensor, signal, power.

1. Testing Seal Of Coolant System

Using air manometer at zero rpm measure that air pressure is declining as a time function.

2. Testing Engine Coolant Flow

Testing coolant flow to engine (lpm), with air manometer. At zero rpm.

3. *Air Flow For Bearing*

Testing airflow to spindle (lpm), with air flow meter. At zero rpm.

4. *Air Flow In Rear Ventilation*

Testing airflow in rear ventilation (lpm) with air flow meter. At zero rpm.

5. Engine Coils Resistance

Testing engine coil resistance (Ω). At zero rpm.

6. Thermistor Resistance

Testing Thermistor resistance (Ω). At zero rpm.

7. Deceleration

Testing deceleration time from 40Krpm to 10Krpm.

8. Sensors-Checking Air Pressure

Testing air pressure with an air manometer. At zero rpm.

9. Sensors-Testing Resistance And Sensor Disconnection

Testing resistance of brush to brush (Ω). At zero rpm.

10. *Vibrations*

Analyze vibrations instrument.

11. Noises

Testing spindle noise with a noise meter.

12. Current

Testing engine current in 3 phases. Will show a chart of current Vs. rotation speed.

13. Voltage

Testing voltage at engine entrance in 3 phases.

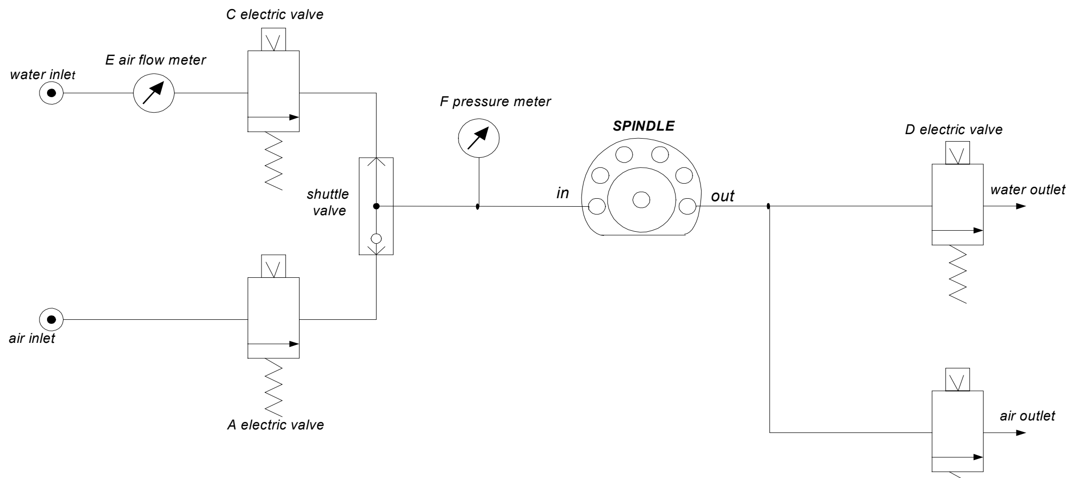
14. Thermal Control Of Spindle

Reading the temperature in 3 points on the spindle including motor thermistor. (The thermistor is a resistor that changes according to temperature change.)

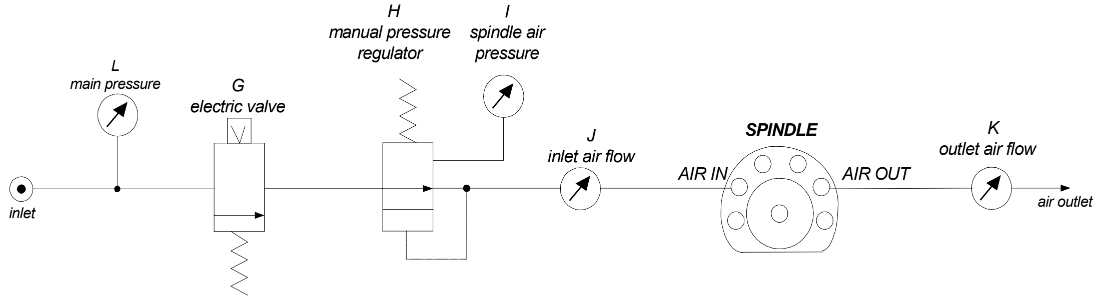
15. Continues Running

Continuous running at maximum speed (allowed), for 48 hours, during which parameters such as speed, current, voltage, temperature etc. will be displayed and monitored, in large time intervals according to need. The test will be based on a sample.

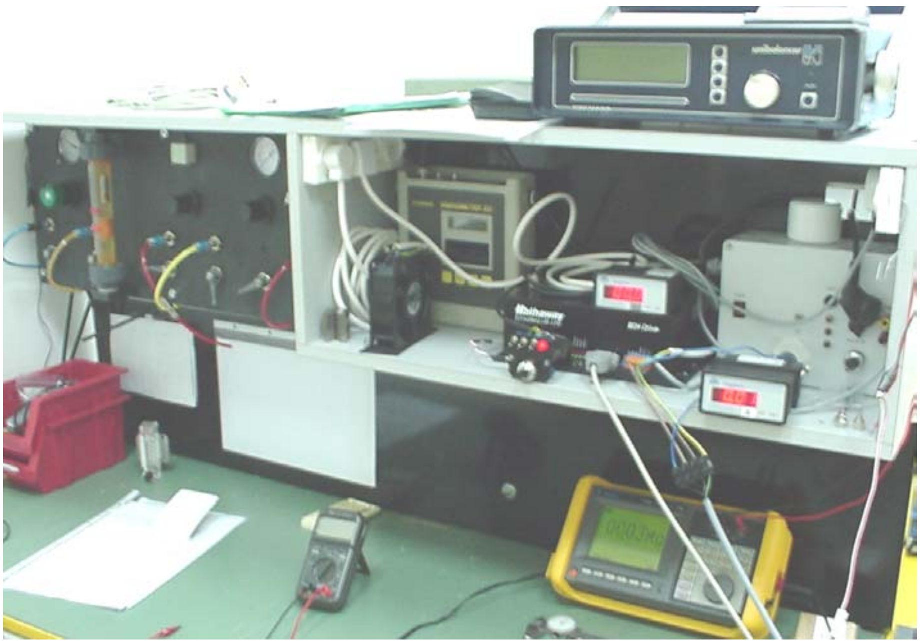
COOLING WATER SEALING & FLOW TEST CIRCUIT



FLOW TEST CIRCUIT



SENSOR PRESSURE TUNING



FAILURE – CAUSE - PREVENTION		
Failure	***Cause***	***Prevention***
The shaft doesn't rotate freely.	- There is dirt or oil in bearing gap - Low air pressure - Air bearings are damaged after crash	- Check the air pressure and air cleaner according to spec. conditions - Air pressure must be 5 Bar. - Return the spindle to the manufacturer for repair
The spindle getting warm	- Low water flow - High temperature of income coolant water - Friction in the bearings - Motor failure - Driver failure - Machine control failure	- Water flow 3 – 5 lpm. - Water temperature 25C max. - Return the spindle to the manufacturer for repair. - Return the spindle to the manufacturer for repair. - Return the driver to the manufacturer for repair. - Return the control unit to the manufacturer for repair.
Spindle shaft rotated too slowly with the same adjustment of speed control unit	- Motor failure - Friction in the bearings - Control unit failure - Driver failure	- Return the spindle to the manufacturer for repair. - Return the spindle to the manufacturer for repair. - Return the control unit to the manufacturer for repair. - Return the driver to the manufacturer for repair.
High vibration level	- The shaft's balancing has changed - Balance of wheel mount was changed - There is dirt on air cover area of the shaft	- Check that spindle shaft is not damaged - Change the wheel mount - Clean the air cover area of the shaft from dirt
The shaft rotates freely, but the spindle does not turn, vibrates or turns too quickly.	- Motor failure - Electrical connections problem (see above)	- Return the spindle to the manufacturer. - Check electrical connections
The shaft rotates freely, but after starting it vibrates.	- Incorrectly connected phases	- Connect phases according to diagram.
Spindle shaft's speed is sharply increased immediately after starting and in this case it's impossible to adjust it.	- Incorrectly connected phases	- Connect phases according to diagram.
The shaft rotates freely, but the spindle does not turn	- Incorrectly connected phases - Hall sensors are incorrectly connected.	- Connect phases according to diagram. - Connect Hall sensors correctly according to diagram

The shaft rotates in air bearings, but not freely, in this case air pressure is normal.	- Air ventilation hole (AO) of spindle is closed by dirt, or sealed, or used small inlet pipe to air out, or this pipe is damaged. - Air ventilation hole (Air out) of brushes sensor (BV) is closed by dirt, or sealed, or used small inlet pipe to air out, or this pipe is damaged.	- Check spindle's air outlet - Check brushes ventilation
Contact resistance of the sensor more than 10 KΩ	- Brushes are too short - Electrical connections problem	- Replace the brushes - Check electrical connections
Short circuit between the brushes	- There is conductive Carbon powder in the contact area of the brushes - Short circuit in brushes cable	- Clean the brushes area. - Check brushes ventilation - Check the brushes cable

Through ISCAR's 50 distributors Colibri has a presence throughout the world.
Five strategically-located offices provide direct support, sales and service.

COLIBRI SPINDLES LTD. – HEADQUARTERS

Lavon Industrial Park, M.P. Bikat Bet Hakerem 25127, Israel

Tel: +972-4-908-1304 • Fax: +972-4-958-9061

E-mail: info@colibrispindles.com • www.colibrispindles.com

COLIBRI

AIR-BEARING SPINDLES